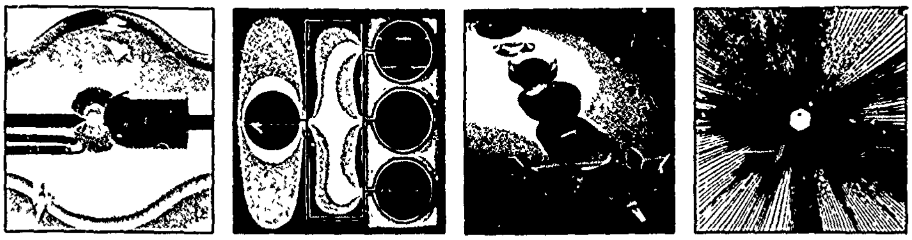

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TECHNICAL REPORT

VOLUME II. Revision.

TRAINER ENGINEERING REPORT (FINAL)

FOR MILES

CDRL ITEM A002

LEVEL II

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Xerox Electro-Optical Systems

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Pasadena, California 91107

FOREWORD

This volume, written at the conclusion of the detailed design, fabrication, and test phases of the Engineering Development contract, is an update of the Trainer Engineering Report (Preliminary)), Data Item A001. This final document reflects the As-built MILES hardware design prior to delivery to OT III in Germany (Fall 1979). It has been updated in March 1981 to include Section 10 which was formerly a separate document, Data Item A00X. *

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Volume II, written at the conclusion of the detailed design, fabrication, and test phases of the Engineering Development contract, is an update of the Trainer Engineering Report (Preliminary), Data Item A001. This final document reflects the As-built MILES hardware design prior to delivery to OT III in Germany (Fall 1979). It has been updated in March 1981 to include Section 10 which was formerly a separate document, Data Item AOOX.

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SECTION 1

INTRODUCTION

This volume of the Trainer Engineering Report presents the ED Hardware design on a system-by-system basis including drawings, sketches, diagrams, and calculations to support design decisions.

Section 1 defines the MILES system hardware requirements, both for ED and the long-term total MILES of the 1980s. Section 2 lists those constraints which affected the MILES system design. The results of the analyses and tradeoff studies from Volume I are summarized as added constraints to the basic system specifications and requirements. In Section 3, the electronics design is discussed including descriptions of those circuits which are basic to all MILES systems. Section 4 describes the eleven systems that comprise the MILES. Subsequent Sections treat the subjects of System Testing (Section 5), Reliability (Section 6), Maintainability (Section 7), EMI Suppression (Section 8), Worst Case Circuit Analysis (Section 9), and Design to Unit Production Cost (Section 10).

1.1 1980 MILES

Engineering Development (ED) design decisions were guided by both product improvement and the ability to expand and to incorporate additional weapon systems applications. The MILES design, while more specifically oriented to ED requirement (small direct fire, and anti-armor weapons), is inherently designed to provide for the addition of other weapon systems and integrated operations in terms of:

a. Compatibility

b. Configuration

c. Pulse Code Design

d. Signal Processing Circuitry

e. Commonality

f. Eye Safety

The MILES of the 1980s is expected to provide for simulation of those weapons and weapon systems listed in table 1-1.

All design activity and decisions for the ED Program were made in terms of their impact on the overall MILES Program of the 1980s.

1.2 ED MILES HARDWARE

To understand the system/assembly mix and match based upon the EDM contractual quantities of devices, two charts were prepared. The first of these charts, table 1-2, depicts the quantities of system/assemblies required for the OT II test program. (Note that this matrix is based on the Army units and type of organization which will be issued the equipment.)

LEGEND:

SA.	SEMI-AUTOMATIC	BL:	BLANK
A.	AUTOMATIC	D:	DUMMY
T	TRACER	API:	ARMOR PIERCING INCENDIARY
B.	BALL	I.	INCENDIARY
SS.	SINGLE SHOT	RKT MTR.	ROCKET MOTOR

54376

WEAPON	TYPE OF FEED	METHOD OF OPERATION / FIRE	MAXIMUM RANGE	MAXIMUM EFFECTIVE RANGE KILL/NEAR MISS (METERS)	MAXIMUM PRACTICAL RANGE	CYCLIC RATE OF FIRE (RPM)	SUSTAINED RATE OF FIRE SEMI/AUTO
SMALL ARMS							
M16A1 RIFLE	20 RD MAG	GAS/AUTO–SA	2650	460/460	460 M	700	15 RPM/20 RPM
M60 MG (7.62)	LINK BELT	GAS/AUTO	3725	800/1100	1100 M	550	100/MIN.
ANTITANK WEAPONS							
LAW	ONE SHOT – DISPOSABLE	ROCKET/SS		300/300	300	N/A	N/A
DRAGON	ONE SHOT – DISPOSABLE	ROCKET/SS	1000 METERS	1000/1000	1000 METERS	N/A	2/MIN.
TOW	MANUAL	ROCKET/SS	3000 METERS	3000/3000	3000 METERS	N/A	2/MIN.
ARMORED PERS. CARR.							
M113							
M2 MG (.50)	LINK BELT	RECOIL/AUTO	6800	800/1600	1600 M	500	40 RPM
MICV							
BUSHMASTER 25 MM	LINK BELT	GAS/AUTO		HE 2000–AP 1800		225	
MG (7.62)	LINK BELT	GAS / AUTO	3650	800/1100	1100 M	550	100/MIN.
TANKS							
105 GUN (M60/A1/A3)	MANUAL	ELECTRIC /SS	4400	3000	3000 M	N/A	N/A
MG (7.62) COAX	LINK BELT	GAS RECOIL/AUTO	N/A	800/1000	1100 M	900	100/MIN.
M85 MG (.50) CUPOLA	LINK BELT	GAS RECOIL/AUTO	1800	800/1600	1800 M	800	40 RPM
105 GUN (XM-1)	MANUAL	ELECTRIC /SS	4400 M	3000		N/A	
MG COAX (7.62)	LINK BELT	GAS RECOIL/AUTO	900 M	800/1100	1100 M	800	100/MIN.
MG CUPOLA (.50) M85	LINK BELT	GAS RECOIL/AUTO	1800 M	800/1600	1600 M	800	40 RPM
152 GUN/MSL (M60A2) (SHERIDAN)	MANUAL	ELECTRIC/SS	3000	2000/2000	3000 M	N/A	N/A
SHILLELAGH MISSILE	MANUAL	ROCKET/SS	3000	3000/3000	3000 M	N/A	N/A
M2 MG (.50) TURRET	LINK BELT	RECOIL/AUTO	6800	800/1600	1600 M	500	40 RPM
M85 MG (.50) CUPOLA	LINK BELT	RECOIL/AUTO	1800	800/1600	1800 M	800	40 RPM
MG COAX (7.62)	LINK BELT	GAS /AUTO	900	800/1100	1100 M	500	100/MIN.
AIR DEFENSE							
REDEYE/STINGER MISSILE	ONE SHOT – DISPOSABLE	SHOOT – THROW AWAY	6000 METERS	4000 METERS	3000 METERS	1/10 SEC	SINGLE SHOT
VULCAN 20 MM GUN	LINKLESS	ELEC. GATLING/AUTO	3000 METERS	1600 METERS	1600 METERS	3000	3000 RPM
CHAPARRAL MISSILE	ONE SHOT	ROCKET	6000	4600 METERS	4500 METERS	1/8 SEC	1/4 SEC.
ROLAND II MISSILE	MAGAZINE	ROCKET	6000	4600 METERS	4500 METERS	1/4 SEC.	1/4 SEC.
AIRCRAFT							
AH-1/ADV ATK HC							
MG (7.62) M134 GATLING	LINK BELT	ELECT. GATLING/AUTO	3200 M	800/1100		2000	2000 RPM
M85 20 MM/30 MM GUN GATLING	LINK BELT	ELECT. GATLING/AUTO	3750 M	1600/1600		750 RPM	100–200/BURST
40 MM GR LCHR	LINK BELT	ELECTRIC/AUTO	2000 M	1200/1300		400 RPM	400 RPM
2.75 ROCKETS	POD LOADED	ROCKET/MULTIPLE	9300 M	2000		21–38	6 PAIRS/SEC.
EXT. RANGE TOW	RACK LOADED	ROCKET / SS	3750 M	3750/3750		SINGLE SHOT	N/A
UH-1/UTTAS							
MG (7.62)	LINK BELT	GAS / AUTO	3725 M	800/1100		550	
OH-58/ADV SCT HC							
MG (7.62) GATLING	LINK BELT	ELECT. GATLING/ AUTO	3725 M	800/1100		2000	N/A
EXT RANGE TOW (ASH)	RACK LOADED	ROCKET/SS	3750 M	3750/3750		SINGLE SHOT	N/A
HELLFIRE (ASH)	RACK LOADED	ROCKET/SS	5000 DIRECT/ 7000 INDIRECT	5000 DIRECT/ 7000 INDIRECT		SS	
ATTACK/FIGHTER (USAF)						N/A	
MAVERICK	RACK LOADED	ROCKET /SS	13 MILES ALT.	4000		N/A	N/A
ROCKEYE (CLUSTER) BOMB	RACK LOADED	FREE FALL/MULT. REL.	6000 FT. ALT	3000		N/A	N/A
30 MM GUN	LINK BELT	ELECT GATLING/AUTO	4000 M	1800		6000 RPM	6000 RPM
30 MM GUN	LINK BELT	HYD. GATLING/AUTO	4000 M	3000		2000–4000	
BOMBS	RACK LOADED	FREE FALL/MULT REL	6000 FT. ALT	3000		N/A	N/A
WALLEYE GBU(-1)	RACK LOADED	GLIDE FALL/ SGL. REL.	10,000 FT. ALT	8000		N/A	N/A
LASER GUIDED BOMBS	RACK LOADED	FREE FALL SGL REL		18,000		N/A	
ENEMY WEAPONS							
SAGGER (ATGM)	MANUAL	ROCKET/SS	3000 METERS	3000	2000 METERS	N/A	SINGLE SHOT
BMP (APC)						N/A	
SAGGER	MANUAL	ROCKET/SS	3000 METERS	3000	3000 METERS	N/A	SINGLE SHOT
73 MM GUN	MANUAL	RECOIL/SS	1000 METERS	1000	1000 METERS	UNK	UNK
ZSU-23-4	LINK BELT	GAS/AUTO	7000 METERS	2000	2500 METERS	2000	200 RPM
LASER GUIDED WEAPONS							
GROUND L.L.D.	N/A	CONT –FLASH/AUTO	10TH RANGING	3000	3K DESIGNATE	N/A	N/A
AIRBORNE L.L.D	N/A	CONT. FLASH AUTO	6K DESIGNATE	3000	3K DESIGNATE	N/A	N/A
LT. WT. L.D.	N/A	CONT. FLASH AUTO	3K DESIGNATE	1000	1K DESIGNATE	N/A	N/A
LANDMINES							
M18A1 ANTI-PERS (CLAYMORE)	N/A	N/A/AUTO	50 METERS	50	50 METERS	N/A	N/A
M16 ANTI-PERS	N/A	N/A/AUTO	30 METERS	30	30 METERS	N/A	N/A
M21 ANTI-TANK	N/A	N/A/AUTO	POINT TARGET	POINT TARGET	POINT TARGET	N/A	N/A
HCPT DEL. AT							
ARTY DEL. AP							
ARTY DEL. AT							

TABLE 1-1
WEAPON CHARACTERISTICS MATRIX

CHARACTERISTICS

RAPID RATE OF FIRE	MAXIMUM RATE OF FIRE	MINIMUM RANGE (DESIRED/ESSENTIAL)	AMMUNITION (TYPE)	FUZE	BURST AREA (EFFECT) INDIRECT/AREA FIRE	FIRE CONTROL SYSTEM (SIGHTS)	BASIC LOAD	TARGET (KILL/NEAR MISS)	TECHNIQUE ENGAGEMEN (BURST RATES
SA (45–60) A (150–200)	SA (15) – A (30)	5/25	B/T		N/A	OPEN	140	1, 6, 7	5 RDS.
200/MIN.	100 MIN.	5/25	B/T/AP/API		N/A	OPEN	600	1, 6, 7, 8	20 RDS.
N/A	1/10 SEC.	10	SHAPE HEAT CHG.	POINT DETONATING	N/A	OPEN	10	1, 3, 4, 5, 8	SINGLE SHOT
4/MIN.	2/MIN.	65 METERS	SHAPE HEAT CHG.	POINT DETONATING	N/A	OPTICAL	2	1, 3, 4, 5, 8	SINGLE SHOT
4/MIN.	2/MIN	50/200	SHAPE HEAT CHG.	POINT DETONATING	N/A	OPTICAL	10	1, 3, 4, 5, 8	SINGLE SHOT
40+ RPM	40 RPM	5/25	B/T/AP/I/ APIT	IMPACT	N/A	OPEN	800	1, 6, 7, 8	20 RDS.
			HEIT/APIT		N/A	OPEN	1200		6 RDS
200/MIN	100/MIN.	5/25	B/T/AP/API	IMPACT	N/A	OPEN	2200	1, 6, 7	20 RDS.
N/A	N/A	50/200	B/BT/AP		N/A	OPTICAL	63	1, 3, 4, 5, 8	SINGLE SHOT
200/MIN.	100 RPM	5/25	BT/API/APIT	IMPACT	N/A	OPTICAL	2200	1, 6, 7	20 RDS.
40+ RPM	40 RPM	5/25	B/T/AP/API/I/BL/D	IMPACT	N/A	OPEN	1200	1, 6, 7, 8	20 RDS.
			SABO/HEAT/HEAT		N/A	OPTICAL	63	1, 3, 4, 5, 8	SINGLE SHOT
200/MIN.	100 RPM	5/25	AP/ B/T/BL/D	IMPACT	N/A	OPTICAL	2200	1, 6, 7	20 RDS.
40+ RPM	40 RPM	5/25	B/T/AP/API/D/BL	IMPACT	N/A	OPEN	800	1, 6, 7, 8	20 RDS.
N/A	N/A	50/200	HE HEAT TP		N/A	OPTICAL	33	1, 3, 4, 5, 8	SINGLE SHOT
N/A	N/A	50/200	AT6M	IMPACT		OPTICAL	13	1, 3, 4, 5, 8	SINGLE SHOT
40+ RPM	40 RPM	5/25	B/T/AP/API/I/BL/D	IMPACT	N/A	OPEN	800	1, 6, 7, 8	20 RPM
80+ RPM	40 RPM	5/25	B/T/AP/API/I/BL/D	IMPACT	N/A	OPEN	1380	1, 6, 7, 8	20 RPM
	100 RPM	5/25	B/T/AP/API/D/BL	IMPACT	N/A	OPTICAL	3000	1, 6, 7	20 RPM
N/A	1 EVERY 10 SEC.	300/500 METERS		IMPACT	N/A	OPEN	6 PER TEAM	6, 7	SINGLE SHOT
10/30/60/100 RPM	1000 RPM	200/250 METERS	HEIT–SD	IMPACT	N/A	OPTICAL	900/1800	1, 6, 7, 8	60 RDS./BURST
1/4 SEC.	1/4 SEC.	800 METERS	HE	PROXIMITY	N/A	OPTICAL	12 PER TRACK	6, 7	1 EVERY 10 SEC.
1/4 SEC.	1/4 SEC.	800 METERS	SHAPE CHARGE	PROXIMITY	N/A	OPTICAL	8 PER TRACK	6, 7	1 EVERY 10 SEC.
4000 RPM	1000 RPM	0	B/T	N/A	N/A	OPTICAL	3000	1, 6, 7	300 RDS.
750 RPM	150 RPM	0	API/HEI	IMPACT	20x55M/20x30M	OPTICAL	850	2, 6, 7, 8	300/100
N/A	400 RPM	300 M	HEDP XM 430	IMPACT	40 X 60 M	OPTICAL	350	1.	7 RDS
6 PAIRS/SEC.	SALVO > 6	300 M	XM 247/XM 261	IMPACT/TIME RG.	10x100M	OPTICAL	14/28/38/76	1, 6, 7, 8	2
N/A	N/A	500 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL WIRE	1	1, 3, 4, 5, 8	SINGLE SHOT
					N/A		800	1, 6, 7	20 RDS.
							2000		[illegible]
N/A	N/A	500 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL REFLEX	4/8	1, 6, 7	80 RDS.
N/A	N/A	50/200 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL	4/8	1, 3, 4, 5, 8	SINGLE SHOT
					N/A	OPTICAL		1, 3, 4, 5, 8	SINGLE SHOT
N/A	N/A	3000 FT ALT	SHAPE CHARGE	IMPACT	N/A	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE SHOT
N/A	N/A	4–500 FT ALT	250–600 BOMBLETS	IMPACT	200 FT RADIUS	REFLEX	1/8	1, 3, 4, 5, 8	2 TO 8
N/A	N/A	0	API/HEI	IMPACT	REP 5 MILS/NED REP 5 MILS/5 MILS	REFLEX	1800	1, 6, 7, 8	100
N/A	N/A	0	HEDP	IMPACT	REP 5 MILS/NED REP 5 MILS/5 MILS	REFLEX	1700	1, 6, 7, 8	80
								1, 6, 7, 8	
N/A	N/A	0	MK82/83/84	IMPACT	• • •	REFLEX	24/12/4	1, 3, 4, 5, 8	4/12/24
N/A	N/A	0	MK82/84	IMPACT	• • •	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE RELEASE
						LASER DESIG.			SINGLE RELEASE
2 RDS/MIN.	2 RDS/MIN.	900 METERS	SHAPE CHARGE	IMPACT	N/A	OPTICAL	3 RDS.	1, 3, 4, 5, 8	SINGLE SHOT
1 RD/MIN.	1 RD/MIN.	500 METERS	SHAPE CHARGE	IMPACT	N/A	OPTICAL	4 RDS.	1, 3, 4, 5, 8	SINGLE SHOT
UNK	UNK	UNK	HEAT	IMPACT	N/A	OPTICAL	30 RDS.	1, 8	UNK
2400 RPM	300 RPM	UNK	API	IMPACT	N/A	OPTICAL	2000	1, 6, 7, 8	20 RDS
								1, 3, 4, 5, 8	
N/A	N/A	300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A
N/A	N/A	300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A
N/A	N/A	300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A
N/A	N/A	NONE	HE		50 M X 2 M X 60°	N/A		1, 8	
N/A	N/A	NONE	HE	50% W/R 30M RADIUS	30 M RADIUS	N/A		1, 8	SINGLE
N/A	N/A	NONE	HE		N/A	N/A		1, 3, 4, 5, 8	SINGLE
								1, 3, 4, 5, 8	SINGLE
								1, 8	
								[illegible]	

BURST AREA (EFFECT) INDIRECT/AREA FIRE	FIRE CONTROL SYSTEM (SIGHTS)	BASIC LOAD	TARGET (KILL/NEAR MISS)	TECHNIQUE OF ENGAGEMENT (BURST RATES)	ON EQUIP. LOAD (AMMO)		REFERENCE MANUALS	REMARKS	REFERE[NCE] DOCUM[ENT]
N/A	OPEN	140	1, 6, 7	5 RDS.			FM23-8		CAT. B 16 AUG
N/A	OPEN	600	1, 6, 7, 8	20 RDS.	880 TO 900		FM23-61		CAT. B 16 AUG
							FM-9-1340-214-10		
N/A	OPEN	10	1, 3, 4, 5, 8	SINGLE SHOT	10 RDS.		TC-23-30		CAT. B, 16 AUG
N/A	OPTICAL	2	1, 3, 4, 5, 8	SINGLE SHOT	10 RDS.		TM-9-1400-470-12		CAT. B, 16 AUG
N/A	OPTICAL	10	1, 3, 4, 5, 8	SINGLE SHOT	10 RDS.				CAT. B, 16 AUG
N/A	OPEN	800	1, 6, 7, 8	20 RDS.			FM 23-65		CAT. B, 16 AUG
N/A	OPEN	1200		5 RDS			[illegible] STUDY		
N/A	OPEN	2300	1, 6, 7	20 RDS.			GRAY		
N/A	OPTICAL	63	1, 3, 4, 5, 8	SINGLE SHOT	63 RDS.		TM9-2300-215		CAT. B, 16 AUG
N/A	OPTICAL	2200	1, 6, 7	20 RDS.	1800 RDS.		TM9-2300-215		CAT. B, 16 AUG
N/A	OPEN	1200	1, 6, 7, 8	20 RDS.	1200 RDS.		TM9-2300-215		CAT. B, 16 AUG
N/A	OPTICAL	60	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL	2200	1, 6, 7	20 RDS.					
N/A	OPEN	900	1, 6, 7, 8	20 RDS.					
N/A	OPTICAL	43	1, 3, 4, 5, 8	SINGLE SHOT	33/20 RDS.		TM9-2300-230-10-2-3		CAT. B, 16 AUG
	OPTICAL	13	1, 3, 4, 5, 8	SINGLE SHOT	13/9 RDS.		TM9-2300-230-10-2-3		CAT. B, 16 AUG
N/A	OPEN	900	1, 6, 7, 8	20 RPM	1300 RDS.				CAT. B, 16 AUG
N/A	OPEN	1080	1, 6, 7, 8	20 RPM	1300 RDS.				CAT. B, 16 AUG
N/A	OPTICAL	3000	1, 6, 7	20 RPM	600 RDS.				CAT. B, 16 AUG
							FM 23-17		
N/A	OPEN	6 PER TEAM	6, 7	SINGLE SHOT	6 PER TEAM				
N/A	OPTICAL	930/1800	1, 6, 7, 8	60 RDS./BURST	1000/300				
N/A	OPTICAL	12 PER TRACK	6, 7	1 EVERY 10 SEC.	12 PER TRACK				
N/A	OPTICAL	6 PER TRACK	6, 7	1 EVERY 10 SEC.	6 PER TRACK				
N/A	OPTICAL	3000	1, 6, 7	200 RDS.			FM 1-40		
20x56M/20x30M	OPTICAL	950	2, 6, 7, 8	200/100			FM 1-40		
40 X 60 M	OPTICAL	200	1.	7 RDS			FM 1-40		
10x100M	OPTICAL	14/28/34/76	1, 6, 7, 8	2			FM 1-40		
N/A	OPTICAL WIRE	1	1, 3, 4, 5, 8	SINGLE SHOT			FM 1-40		
N/A		600	1, 6, 7	20 RDS.			FM 1-40		
		2000		6					
N/A	OPTICAL REFLEX	4/8	1, 6, 7	80 RDS.			FM 1-40		
N/A	OPTICAL	4/8	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL		1, 3, 4, 5, 8	SINGLE SHOT					
N/A	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE SHOT					
200 FT. RADIUS	REFLEX	1/8	1, 3, 4, 5, 8	2 TO 8					
7/2P 5 MILS/NED REP 5 MILS/5 MILS	REFLEX	1000	1, 6, 7, 8	100					
REP 5 MILS/NED REP 5 MILS/5 MILS	REFLEX	1380	1, 6, 7, 8	60					
			1, 6, 7, 8						
• • •	REFLEX	24/12/4	1, 3, 4, 5, 8	4/12/24					
• • •	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE RELEASE					
	LASER DESIG.			SINGLE RELEASE					
N/A	OPTICAL	3 RDS.	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL	4 RDS.	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL	30 RDS.	1, 8	UNK					
N/A	OPTICAL	3000	1, 6, 7, 8	20 RDS					
			1, 3, 4, 5, 8						
N/A	OPTICAL	N/A		N/A					
N/A	OPTICAL	N/A		N/A					
N/A	OPTICAL	N/A		N/A					
50 M X 2 M X 60°	N/A		1, 8						
30 M RADIUS	N/A		1, 8	SINGLE					
N/A	N/A		1, 3, 4, 5, 8	SINGLE					
			1, 3, 4, 5, 8	SINGLE					

MG (7.62) COAX	LINK BELT							
M85 MG (.50) CUPOLA	LINK BELT	GAS RECOIL/AUTO	1500	800/1600	1600 M	800		
105 GUN (XM-1)	MANUAL	ELECTRIC/SS	4400 M	3000		N/A		
MG COAX (7.62)	LINK BELT	GAS RECOIL/AUTO	900 M	800/1100	1100 M	800	100/MIN.	2
MG CUPOLA (7.62) M85	LINK BELT	GAS RECOIL/AUTO	1600 M	800/1600	1600 M	800	40 RPM	4
152 GUN/MSL (M551) (SHERIDAN)	MANUAL	ELECTRIC/SS	2800	2000/2000	2000 M	N/A	N/A	
SHILLELAGH MISSILE	MANUAL	ROCKET/SS	3000	3000/3000	3000 M	N/A	N/A	
M2 MG (.50) TURRET	LINK BELT	RECOIL/AUTO	6800	800/1600	1600 M	500	40 RPM	
M85 MG (.50) CUPOLA	LINK BELT	RECOIL/AUTO	1600	800/1600	1600 M	800	40 RPM	
MG COAX (7.62)	LINK BELT	GAS /AUTO	900	800/1100	1100 M	500	100/MIN.	
AIR DEFENSE								
REDEYE/STINGER MISSILE	ONE SHOT – DISPOSABLE	SHOOT – THROW AWAY	6000 METERS	4000 METERS	3000 METERS	1/10 SEC	SINGLE SHOT	
VULCAN 20 MM GUN	LINKLESS	ELEC. GATLING/AUTO	3000 METERS	1600 METERS	1600 METERS	3000	2000 RPM	10/30
CHAPARRAL MISSILE	ONE SHOT	ROCKET	6000	4600 METERS	4500 METERS	1/8 SEC	1/4 SEC.	
ROLAND II MISSILE	MAGAZINE	ROCKET	6000	4600 METERS	4000 METERS	1/4 SEC.	1/4 SEC.	
AIRCRAFT								
AH-1/ADV ATK HC								
MG (7.62) M134 GATLING	LINK BELT	ELECT GATLING/AUTO	3200 M	800/1100		2000	2000 RPM	4
M86 20 MM/30 MM GUN GATLING	LINK BELT	ELECT. GATLING/AUTO	3750 M	1000/1000		750 RPM	100–200/BURST	
40 MM GR LCHR	LINK BELT	ELECTRIC/AUTO	2000 M	1200/1200		400 RPM	400 RPM	
2.75 ROCKETS	POD LOADED	ROCKET/REPLSIVE	9300 M	2000		21–38	6 PAIRS/SEC.	6
EXT. RANGE TOW	RACK LOADED	ROCKET / SS	3750 M	3750/3750		SINGLE SHOT	N/A	
UH-1/UTTAS								
MG (7.62)	LINK BELT	GAS / AUTO	3725 M	800/1100		900		
OH-58/ADV SCT HCPTR								
M3 (7.62) GATLING	LINK BELT	ELECT. GATLING/ AUTO	3725 M	800/1100		2000	N/A	
EXT RANGE TOW (ASH)	RACK LOADED	ROCKET/SS	3750 M	3750/3750		SINGLE SHOT	N/A	
HELLFIRE (ASH)	RACK LOADED	ROCKET/SS	5000 DIRECT/ 7000 INDIRECT	5000 DIRECT/ 7000 INDIRECT		16		
ATTACK/FIGHTER (USAF)						N/A		
MAVERICK	RACK LOADED	ROCKET/SS	13 MILES ALT.	4000		N/A	N/A	
ROCKEYE (CLUSTER BOMB)	RACK LOADED	FREE FALL/MULT REL	6000 FT ALT.	3000		N/A	N/A	
20 MM GUN	LINK BELT	ELECT GATLING/AUTO	4000 M	1000		6000 RPM	6000 RPM	
30 MM GUN	LINK BELT	HYD. GATLING/AUTO	4000 M	3000		2000–4000		
BOMBS	RACK LOADED	FREE FALL/MULT REL	6000 FT. ALT	3000		N/A	N/A	
WALLEYE GBU(1)	RACK LOADED	GLIDE FALL/ SGL. REL.	10,000 FT ALT	8000		N/A	N/A	
LASER GUIDED BOMBS	RACK LOADED	FREE FALL/SGL REL		18,000		N/A		
ENEMY WEAPONS								
SAGGER (AT0000)	MANUAL	ROCKET/SS	3000 METERS	3000	3000 METERS	N/A	SINGLE SHOT	
BMP (APC)						N/A		
SAGGER	MANUAL	ROCKET / SS	3000 METERS	3000	3000 METERS	N/A	SINGLE SHOT	
73 MM GUN	MANUAL	RECOIL/SS	1000 METERS	1000	1000 METERS	UNK	UNK	
ZSU-23-4	LINK BELT	GAS/AUTO	7000 METERS	3800	2500 METERS	2000	200 RPM	
LASER GUIDED WEAPONS								
GROUND L.L.D.	N/A	CONT.–FLASH/AUTO	WITH RANKING	3000	3K DESIGNATE	N/A	N/A	
AIRBORNE L.L.D.	N/A	CONT. FLASH AUTO	3K DESIGNATE	3000	3K DESIGNATE	N/A	N/A	
LT. WT. L.D.	N/A	CONT. FLASH/AUTO	3K DESIGNATE	1000	1K DESIGNATE	N/A	N/A	
LANDMINES								
M18A1 ANTI-PERS (CLAYMORE)	N/A	N/A/AUTO	50 METERS	50	50 METERS	N/A	N/A	
M16 ANTI-PERS	N/A	N/A/AUTO	30 METERS	30	30 METERS	N/A	N/A	
M21 ANTI-TANK	N/A	N/A/AUTO	POINT TARGET	POINT TARGET	POINT TARGET	N/A	N/A	
HCPT DEL. AT								
ARTY DEL. AP								
ARTY DEL. AT								
VEH DEL. AT/AP								
INDIRECT FIRE								
CONV ROUNDS								
			1814 1000 1472 1814					
81 MM MORTAR	MANUAL GRAVITY	GRAVITY/SS	4737 3150 4737 3552	4000			30 PER MIN. FOR	
4.2 INCH MORTAR	MANUAL GRAVITY	GRAVITY/SS	5650 5490 5650 –	8000			18 PER MIN. FOR	
105 MM HOW.	MANUAL	RECOIL MAN/SS	11,000 M	11,000	N/A	N/A	10 PER MIN. FOR	
155 MM HOW.	MANUAL HYDRAULIC	RECOIL MAN/SS	14,000 M	14,000			4 PER MIN. FOR	
8 INCH CANNON	MANUAL HYDRAULIC	MANUAL/SS	16,000 M	16,800			2 PER MIN. FOR	
CHEMICAL WEAPONS	UNK							
NUCLEAR WPN EFF	UNK							
TARGETS								
1 INDIVIDUAL SOLDIER (EXPOSED)								
2. ANTITANK WEAPONS								
3. ARMORED PERSONNEL CARRIERS								
4. TANKS								
5. AIR DEFENSE WEAPONS								
6. HELICOPTERS								
7 ATTACK/FIGHTER AIRCRAFT								
8. WHEELED VEHICLES								

	SABO/HEI-T/HEAT		N/A	OPTICAL					
5/25	AP/ B/T/BL/D	IMPACT	N/A	OPTICAL	2200	1, 6, 7	20 RDS.		
5/25	B/T/AP/APL/D/BL	IMPACT	N/A	OPEN	800	1, 6, 7, 8	20 RDS.		
80/200	HE HEAT TP		N/A	OPTICAL	33	1, 3, 4, 5, 8	SINGLE SHOT	33/80 RDS.	
50/200	ATSM	IMPACT		OPTICAL	13	1, 3, 4, 5, 8	SINGLE SHOT	13/8 RDS.	
5/25	B/T/AP/API/I/BL/D	IMPACT	N/A	OPEN	800	1, 6, 7, 8	20 RPM	1300 RDS.	
5/25	B/T/AP/API/I/BL/D	IMPACT	N/A	OPEN	1000	1, 6, 7, 8	30 RPM	1300 RDS.	
5/25	B/T/AP/API/D/BL	IMPACT	N/A	OPTICAL	3000	1, 6, 7	30 RPM	600 RDS.	
300/500 METERS		IMPACT	N/A	OPEN	6 PER TEAM	6, 7	SINGLE SHOT	6 PER TEAM	
200/250 METERS	HEIT-SD	IMPACT	N/A	OPTICAL	900/1800	1, 6, 7, 8	60 RDS./BURST	1000/300	
800 METERS	HE	PROXIMITY	N/A	OPTICAL	12 PER TRACK	6, 7	1 EVERY 10 SEC.	12 PER TRACK	
800 METERS	SHAPE CHARGE	PROXIMITY	N/A	OPTICAL	8 PER TRACK	6, 7	1 EVERY 10 SEC.	3 PER TRACK	
0	B/T	N/A	N/A	OPTICAL	3000	1, 6, 7	300 RDS.		
0	API/HEI	IMPACT	20x56M/20x30M	OPTICAL	960	2, 6, 7, 8	300/100		
300 M	HEDP XM 430	IMPACT	40 X 60 M	OPTICAL	200	1.	7 RDS		
300 M	XM 247/XM 361	IMPACT/TIME RG.	10x100M	OPTICAL	14/28/36/76	1, 6, 7, 8	2		
500 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL WIRE	1	1, 3, 4, 5, 8	SINGLE SHOT		
			N/A		600	1, 6, 7	30 RDS.		
					3000		0		
500 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL REFLEX	4/8	1, 6, 7	80 RDS.		
50/200 M	SHAPE CHARGE	IMPACT	N/A	OPTICAL	4/8	1, 3, 4, 5, 8	SINGLE SHOT		
			N/A	OPTICAL		1, 3, 4, 5, 8	SINGLE SHOT		
3000 FT. ALT.	SHAPE CHARGE	IMPACT	N/A	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE SHOT		
4-500 FT. ALT.	250-600 BOMBLETS	IMPACT	200 FT. RADIUS	REFLEX	1/6	1, 3, 4, 5, 8	2 TO 8		
0	API/HEI	IMPACT	REP 9 MILS/NED REP 5 MILS/5 MILS	REFLEX	1000	1, 6, 7, 8	100		
0	HEDP	IMPACT	REP 9 MILS/NED REP 5 MILS/5 MILS	REFLEX	1300	1, 6, 7, 8	80		
						1, 6, 7, 8			
0	MK82/83/84	IMPACT	• • •	REFLEX	24/12/4	1, 3, 4, 5, 8	4/12/24		
0	MK82/84	IMPACT	• • •	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE RELEASE		
				LASER DESIG.			SINGLE RELEASE		
900 METERS	SHAPE CHARGE	IMPACT	N/A	OPTICAL	3 RDS.	1, 3, 4, 5, 8	SINGLE SHOT		
900 METERS	SHAPE CHARGE	IMPACT	N/A	OPTICAL	4 RDS.	1, 3, 4, 5, 8	SINGLE SHOT		
UNK	HEAT	IMPACT	N/A	OPTICAL	30 RDS.	1, 8	UNK		
UNK	API	IMPACT	N/A	OPTICAL	3000	1, 6, 7, 8	30 RDS		
						1, 3, 4, 5, 8			
300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A		
300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A		
300 METERS	LASER	N/A	N/A	OPTICAL	N/A		N/A		
NONE	HE		50 M X 2 M X 60°	N/A		1, 8			
NONE	HE	50% W/R 30M RADIUS	30 M RADIUS	N/A		1, 8	SINGLE		
NONE	HE		N/A	N/A		1, 3, 4, 5, 8	SINGLE		
						1, 3, 4, 5, 8	SINGLE		
						1, 8			
						1, 3, 4, 5, 8			
						1, 3, 4, 5, 8			
						1, 3, 5, 8			
46 375 36 45	HE ILLUM WP TP	30 M DIA 10 M DIA				1, 3, 5, 8			
75 100 75 82	HE ILLUM WP TP	34 1100 20 -	34 M DIA.	N/A	80/1161	1, 3, 5, 8	36/30 RPM		
920 400 920 -	HE ILLUM WP	40 x 20 (HE) 1500 DIA (I)	30 X 40 M	N/A	90/1031	1, 3, 5, 8	18/8 RPM		
1000 M	HE/ICM	IMPACT	30 X 30 M	N/A	72	1, 3, 5, 8	10/3 RPM		
2000 M	HE/ICM	IMPACT	30 X 50 M	N/A	20	1, 3, 5, 8	4/1 RPM		
3000 M	HE/ICM	IMPACT	30 X 80 M	N/A	2	1, 3, 4, 5, 8	1 RPM		
						1			
			ICM			1			
			150-150 M DIA						
			155-120 M DIA						
			8"-130 M DIA						

• • •

	MAE F² P ,RS			
	S	P	F	T
MK82	30,000	15,000	2500	K2.3/
MK83	50,000	24,000	5000	K3.6/
MK84				

N/A	OPTICAL	2200	1, 6, 7	20 RDS.					
N/A	OPEN	900	1, 6, 7, 8	20 RDS.					
N/A	OPTICAL	33	1, 3, 4, 5, 8	SINGLE SHOT	33/30 RDS.		TM9-2300-330-10-2-3		CAT. B, 25 AMB
	OPTICAL	13	1, 3, 4, 5, 8	SINGLE SHOT	11/9 RDS.		TM9-2300-230-10-2-3		CAT. B, 16 AMB
N/A	OPEN	900	1, 6, 7, 8	20 RPM	1300 RDS.				CAT. B, 16 RAB
N/A	OPEN	1090	1, 6, 7, 8	20 RPM	1300 RDS.				CAT. B, 16 AMB
N/A	OPTICAL	3000	1, 6, 7	20 RPM	600 RDS.				CAT. B, 16 AMB
							FM 23–17		
N/A	OPEN	6 PER TEAM	6, 7	SINGLE SHOT	6 PER TEAM				
N/A	OPTICAL	900/1800	1, 6, 7, 8	60 RDS./BURST	1000/300				
N/A	OPTICAL	12 PER TRACK	6, 7	1 EVERY 10 SEC.	12 PER TRACK				
N/A	OPTICAL	8 PER TRACK	6, 7	1 EVERY 10 SEC.	8 PER TRACK				
N/A	OPTICAL	3000	1, 6, 7	200 RDS.			FM 1–40		
20x56M/20x30M	OPTICAL	950	2, 6, 8	200/100			FM 1–40		
40 X 60 M	OPTICAL	200	1,	7 RDS			FM 1–40		
10x100M	OPTICAL	14/28/35/76	1, 6, 7, 8	2			FM 1–40		
N/A	OPTICAL WIRE	1	1, 3, 4, 5, 8	SINGLE SHOT			FM 1–40		
N/A		600	1, 6, 7	20 RDS.			FM 1–40	6	
		2000		4					
N/A	OPTICAL REFLEX	4/8	1, 6, 7	80 RDS.			FM 1–40		
N/A	OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL		1, 3, 4, 5, 8	SINGLE SHOT					
N/A	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE SHOT					
200 FT RADIUS	REFLEX	1/8	1, 3, 4, 5, 8	2 TO 8		1			
REP 5 MILS/MED REP 5 MILS/5 MILS	REFLEX	1000	1, 6, 7, 8	100					
REP 5 MILS/MED REP 5 MILS/5 MILS	REFLEX	1300	1, 6, 7, 8	80					
			1, 6, 7, 8						
• • •	REFLEX	24/12/4	1, 3, 4, 5, 8	4/12/24					
• • •	ELECTRO-OPTICAL	4/6	1, 3, 4, 5, 8	SINGLE RELEASE					
	LASER DESIG.			SINGLE RELEASE					
N/A	OPTICAL	3 RDS.	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL	4 RDS.	1, 3, 4, 5, 8	SINGLE SHOT					
N/A	OPTICAL	30 RDS.	1, 8	UNK					
N/A	OPTICAL	3000	1, 6, 7, 8	20 RMS					
			1, 3, 4, 6, 8						
N/A	OPTICAL	N/A		N/A					
N/A	OPTICAL	N/A		N/A					
N/A	OPTICAL	N/A		N/A					
50 M X 2 M X 60°	N/A		1, 8						
30 M RADIUS	N/A		1, 8	SINGLE					
N/A	N/A		1, 3, 4, 5, 8	SINGLE					
			1, 3, 4, 5, 8	SINGLE					
			1, 8						
			1, 3, 4, 5, 8						
			1, 3, 4, 5, 8						
			1, 3, 5, 8						
			1, 3, 5, 8						
34 M DIA.	N/A	80/1161	1, 3, 5, 8	28/30 RPM			FM 101-10-1	STD "A" AMMO	
30 X 40 M	N/A	30/1031	1, 3, 5, 8	18/8 RPM			FM 101-10-1	STD "A" AMMO	
20 X 30 M	N/A	73	1, 3, 5, 8	10/3 RPM			ST 7-163		
30 X 50 M	N/A	28	1, 3, 5, 8	4/1 RPM			ST 7-163		
30 X 80 M	N/A	2	1, 3, 4, 5, 8	1 RPM			ST 7-163		
			1						
			1						

IC%
130–150 M DIA
155–120 M DIA
8?–130 M DIA

	• • •			• • •	
	MAE F² PERS				
	S	P	F	TSI	AA
MK82	30,000	15,000	2500	K2.5/MF 4.4	9 000
MK81	50,000	24,000	3000	K3.6/MF 6.9	17,000
MK81					

TABLE 1-2

OT II TEST PLAN
ORGANIZATION/HARDWARE

Systems and Assemblies	Company	MECHANIZED INFANTRY COMPANY (ONE)									ARMOR COMPANY (ONE)				COMMAND VEHICLES	TRADER REQUIREMENTS: WEAPON SIMULATORS TOTALS	TRADER REQUIREMENTS: GFE VEHICLES TOTALS		CONTRACT: WEAPON SIMULATORS TOTALS	CONTRACT: ADAPTER KITS
	Platoon	1st Platoon			2nd Platoon			3rd Platoon			1st Platoon	2nd Platoon	3rd Platoon	Extra Platoon		10 each A17A63 Controller Gun A17A64 Field Tester	OT II	OT II	13 each A17A63 Controller Gun A17A64 Field Tester	
	Squads	1	2	3	1	2	3	1	2	3										
APCs (13) (includes CVKI and CVLD) (A17A62) M113 APCs	Squad M113 APCs	1	1	1	1	1	1	1	1	1					4	*** See Below	13 APCs	(-0-)	***	***
	M2 - 50 Cal Machine Gun	1	1	1	1	1	1	1	1	1					4	25	6 TOW APCs	(4)	** 29	M2 Machine Gun 17A43 29
TOW APCs (6) (includes CVLD and CVKI) (A17C6) TOW APC	M2 - 50 Cal Machine Gun	2			2			2												
TOW APC	TOW	2			2			2								6		(2)	8	TOW 17A48 8
M60A1/A3 Tanks (A17B8)	M60A1 (incl. CVLD and CVKI)										5	5	5			41 ***		(6)	*** 47 each	***
											1 Float (or Co. Cmdr. Tank)									
	105 mm Main Gun										5	5	5			16	16 M60A1 Tanks	(2)	18	105 mm 18
											1 Float									
	7.62 mm Coax MG										5	5	5			** 22		(4)	** 26	** M73 - 17A42 26
											1 Float									
	M85 - 50 Cal MG										5	5	5			* 16		(2)	18	M85 - 18
											1 Float									
M551 AARV (A17B10)	M551 (incl. CVLD and CVKI)													5		*** See Above			***	***
														1 Float						
	152 mm Main Gun													5		6 (17A53)	6 M551 Tanks	(2)	8	152 mm 8
														1 Float						
	7.62 mm Coax MG													5		** Included Above			**	**
														1 Float						
	M2 MG 50 Cal													5		* Included Above			*	*
														1 Float						
DRAGON (A17C5) (Have MWLD but do not have M16A1 Rifles)		1	1	1	1	1	1	1	1	1						10 (17A54)	10 DRAGON Weapons	(2)	12	
		1 Float																		
VIPER (A17C7) (Riflemen with M16A1 Rifles and MWLDs)		2	2	2	2	2	2	2	2	2						20 (17A56)	20 VIPER Weapons	(3)	23	
		2 Floats																		
M16A1 Rifles (5.56 mm) (Part of A17A60)	TOW Crews (2)	8 Rifles			8 Rifles			8 Rifles												
Squad Leader (1) Team Leader (2) Individual Rifleman (5)	Squads	8	8	8	8	8	8	8	8	8						110	110 M16A1 Rifles	(10)	120	M16A1 Adapter Kit 120
None for APC Driver None for DRAGON Gunner None for 2 Man Machine Gun Team		1 (Platoon Leader)			1			1												
		[illegible]																		

50 Cal														1 Float					
DRAGON (A17C5) (Have MWLD but do not have M16A1 Rifles)		1	1	1	1	1	1	1	1	1						10 (17A54)	10 (2) DRAGON Weapons	12	
		1 Float																	
VIPER (A17C7) (Riflemen with M16A1 Rifles and MWLDs)		2	2	2	2	2	2	2	2	2						20 (17A56)	20 (3) VIPER Weapons	23	
		2 Floats																	
M16A1 Rifles (5.56 mm) (Part of A17A60)	TOW Crews (2)	8 Rifles			8 Rifles			8 Rifles											
Squad Leader (1) Team Leader (2) Individual Riflemen (5)	Squads	8	8	8	8	8	8	8	8	8						110	110 (10) M16A1 Rifles	120	M16 Adapter Kit 120
None for APC Driver None for DRAGON Gunner None for 2 Man Machine Gun Team		1 (Platoon Leader)			1			1											
		11 Floats (Platoon Sgts., RTOs, Comm. Section Personnel)																	
M60 Machine Gun (7.62 mm) (A17A61)		1	1	1	1	1	1	1	1	1						10	10 (2) M60 MG	12	12
		1 Float																	
MWLD (Part of A17A60)*	Tank Crew										10	10	10	10					
											2 Floats			2 Floats					
	M60 MG	1	1	1	1	1	1	1	1	1						190	190 (10) Men + 22 x 1 (Tanks) + 19 x 1 (APC Drivers)	200	-0-
		2 Floats																	
	TOW Crews	8			8			8											
	DRAGON Crews	1	1	1	1	1	1	1	1	1									
		1 Float																	
Leaders and Riflemen		8	8	8	8	8	8	8	8	8									
Squad Leader (1) Team Leader (2) Riflemen (5)		1 Platoon Leader			1			1											
		26 Floats (Platoon Sgts., RTOs, Comm. Sect., Maintenance)																	

The total ED contractually required hardware was derived from table 1-2 and is shown in matrix form in table 1-3. The organization of this chart is by system and by assemblies within the systems. This matrix shows the mix of assemblies and the type of adapters required. The field tester shown in table 1-3 was eliminated as a requirement after OT II and prior to OT III testing.

The ED MILES systems are shown conceptually in figures 1-1 through 1-3. The major assemblies that are used throughout the various MILES systems are depicted in figure 1-4.

Table 1-4, Nomenclature, is included as an aid to the reader. The MILES official nomenclature is compared to the common names which are used throughout the text.

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Table 1-3. ED Hardware Matrix

Assemblies / Systems →	System Qty. for ED DT II / MILES Contract Schedule Section E - Qty. ED MILES	M16A1 Rifle A17A60	M60 Machine Gun A17A61	M60A1/A3 Tank A17B8	DRAGON A17C5	M60A2 Tank A17B9	M551 AARV A17BD	VIPER A17C7		TOW M113 A17C6	M113 APC (M2) A17A62		Controller Gun A17A63	Field Tester A17A64
DT II		(110)	(10)	(18)	(10)	0	(6)	(20)		(6)	(13)		(15)	(10)
System Qty.		88	12	18	12	-0-	8	23		8	13		18	13
for ED DT II		(10)	(2)	(2)	(2)	0	(2)	(3)		(2)	(0)		(3)	(3)
Laser Transmitter, M16A1 Rifle (5.56 mm)	120 (88+ 32)	1								4				
Laser Transmitter, M60 Machine Gun (7.62 mm)	12		1											
Laser Transmitter, Coax Machine Gun (7.62 mm)	26			1			1							
Laser Transmitter, M2 Machine Gun (50 Cal)	29						1			1	1			
Laser Transmitter, M85 Machine Gun (50 Cal)	18			1		(1)								
Laser Transmitter, 105 mm Gun	18			1										
Laser Transmitter, Shillelagh (152 mm)	8					(1)	1							
Laser Transmitter, 152 mm Gun	8					(1)	1							
Laser Transmitter, Dragon Missile	12				1									
Laser Transmitter, TOW Missile	8									1				
Laser Transmitter, VIPER Missile	23							1						
Laser Detector, Man Worn (MWLD)	196	1	1	2	1	(2)	2			4				
Laser Detector, Combat Vehicle (CVLD) — Belt Set	47			1		(1)	1			1	1			
Laser Detector, Combat Vehicle (CVLD) — Loader Control Assy.	34			1		(1)	1			1				
Laser Detector, Combat Vehicle (CVLD) — Control Indicator Assy.	13										1			
Kill Indicator, Combat Vehicle (CVKI)	47			1		(1)	1			1	1			
Controller Gun and Controller Key	18												1	
Field Tester	13													1
Adapter Kit, M113 APC/M2	21									1	1			
Adapter Kit, M60A1/A3 Tank	18			1										
Adapter Kit, M551 AARV	8						1							
Adapter Kit, APC/TOW	8									1				
Spare Weapon Keys (4)	52			2		(2)	2							
Adapter Kit, M60A2	-0-					(1)								
System Totals		120 (88+ 32)	12	18	12	0	8	23		8	13		18	13

Notes: 1. The M60A2 system is designed but no hardware fabrication for E.D.
2. 32 M16A1 Rifle systems are in TOW APC subsystem
3. One assembly, chamber mounted, includes all weapon simulators thus shown.

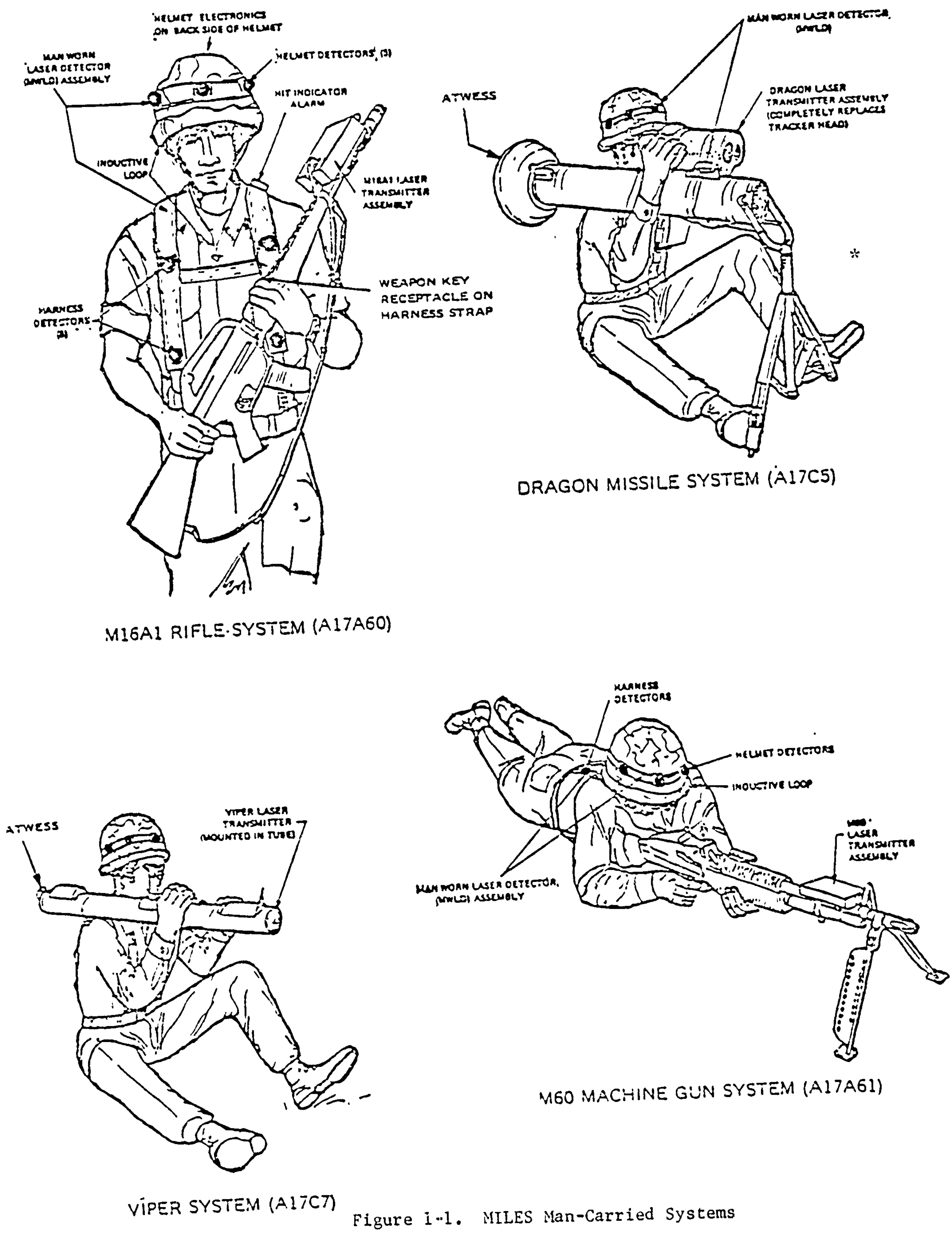

Figure 1-1. MILES Man-Carried Systems

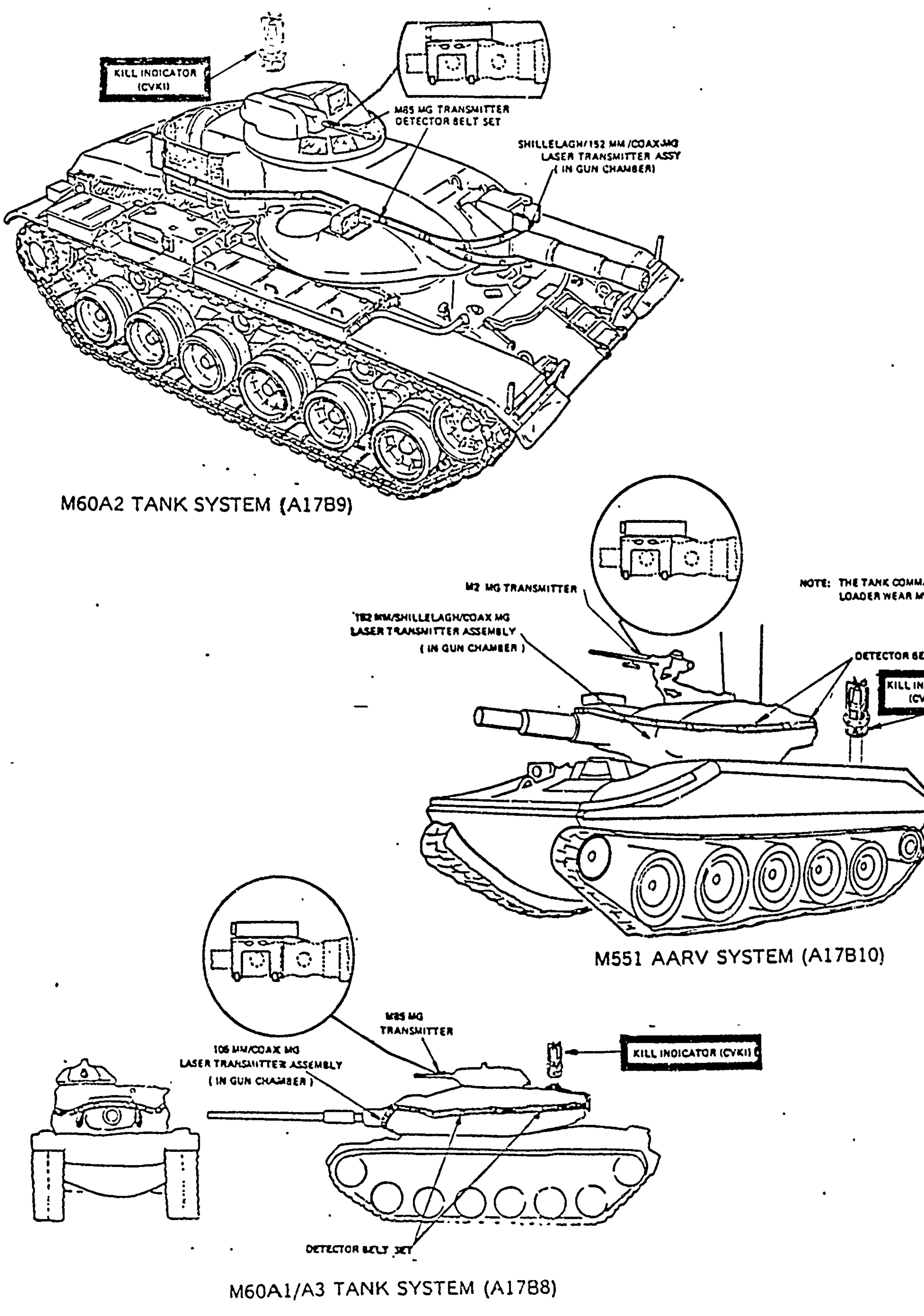

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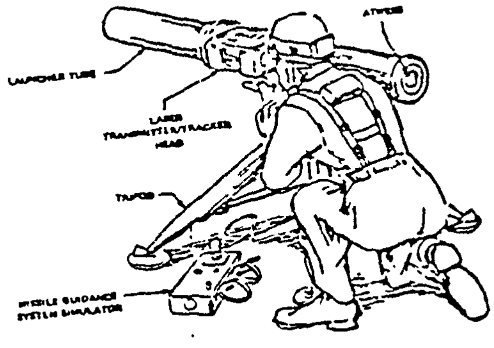
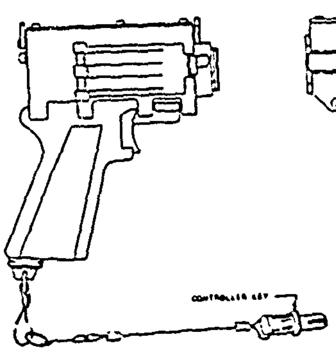
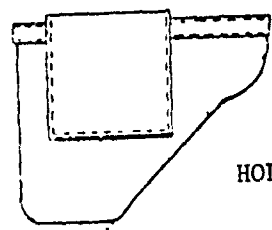
Figure 1-2. MILES Tank Systems



TOW SYSTEM

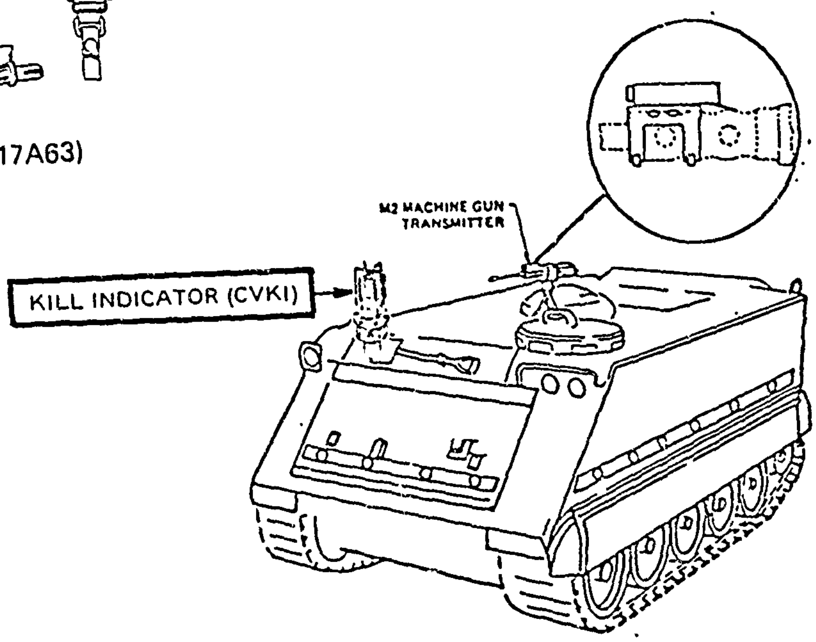


CONTROLLER GUN (A17A63)



HOLSTER

*



M113 APC/M2 SYSTEM (A17A62)

Figure 1-3. MILES Controller Gun, M113 Vehicle, and TOW Systems

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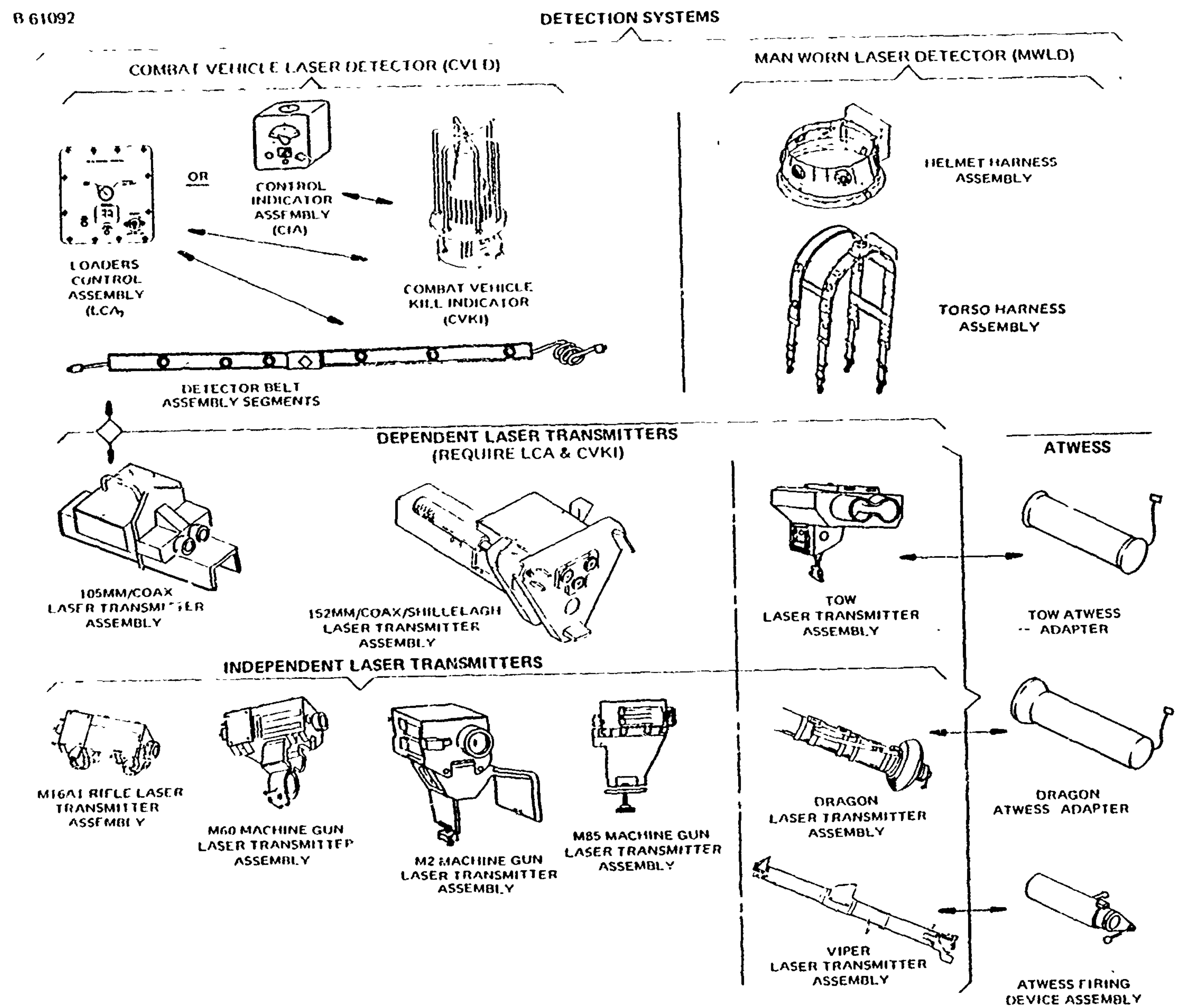

Figure 1-4. MILES Major Assemblies

Table 1-4. Nomenclature

MILES OFFICIAL NOMENCLATURE	MILES COMMON NAME(S)
Simulator System, Firing, Laser: XM60 for M16A1 Rifle	M16A1 Rifle Transmitter System M16 Rifle System
Simulator System, Firing, Laser: XM61 for M60 Machine Gun	M60 Machine Gun Transmitter System M60 Machine Gun System
Simulator System, Firing, Laser: XM63 for M113 APC	M113 APC Simulator System M113 APC System
Simulator System, Firing, Laser: XM65 for M60A1/A3 Tank	M60A1/A3 Tank Simulator System M60A1 Tank System
Simulator System, Firing, Laser: XM66 for M60A2 Tank	M60A2 Tank Simulator System M60A2 Tank System
Simulator System, Firing, Laser: XM67 for M551 Vehicle	M551 Vehicle Simulator System M551 Vehicle System
Simulator System, Firing, Laser: XM62 for DRAGON Missile	DRAGON Simulator System DRAGON System
Simulator System, Firing, Laser, XM64 for TOW	TOW Simulator System Independent TOW *
Simulator System, Firing, Laser: XM68 for LAW/VIPER Rocket	VIPER Simulator System VIPER System
Controllers Gun, Simulator System, Laser	Controller Gun
Transmitter Assy, Simulator System, Laser: for M16A1 Rifle	M16A1 Laser Transmitter M16 Transmitter
Detector Assy, Simulator System, Laser: Man Worn	Man Worn Laser Detector (MWLD)
Transmitter Assy, Simulator System, Laser: For M60 Machine Gun	M60 Machine Gun Laser Transmitter M60 Transmitter
Transmitter Assy, Simulator System, Laser: For M2 Machine Gun	M2 Machine Gun Laser Transmitter M2 Transmitter
Console, Simulator System, Laser: For M113 APC	Control Indicator Assembly (CIA) Control Indicator

Table 1-4. Nomenclature (Cont.)

MILES OFFICIAL NOMENCLATURE	MILES COMMON NAME(S)
Indicator, Simulator System, Laser: Combat Vehicle Kill/Hit/Miss	Combat Vehicle Kill Indicator (CVKI)
Transmitter Assy, Simulator System, Laser: For M85 Machine Gun	M85 Machine Gun Laser Transmitter M85 Transmitter
Transmitter Assy, Simulator System, Laser: 105MM/Coax	105MM/Coax Laser Transmitter Assy 105MM/Coax Transmitter Assy
Console, Simulator System, Laser: For M113 TOW/M60 Tanks/M551 Vehicle	Control Console Loaders Control Assy (LCA)
Transmitter Assy, Simulator System, Laser: For 152MM/Shillelagh/Coax	152MM/Coax/Shillelagh Laser Transmitter Assembly 152MM/Coax/Shillelagh Transmitter Assy
Transmitter Assy, Simulator System, Laser: For DRAGON Missile	DRAGON Laser Transmitter Assy DRAGON Transmitter
Transmitter Assy, Simulator System, Laser: For TOW Missile	TOW Laser Transmitter Assy TOW Transmitter

SECTION 2

DESIGN CONSTRAINTS

2.1 INTRODUCTION

In the MILES system there were a number of constraints which impacted the design. These and other criteria are defined in the system specification NTEC No. 2234-122 and documents referenced in that specification. Among the more important design constraints were:

a. False alarm rate

b. Weapon characteristics to be simulated

c. Eye safety limitations on transmitter power

d. Design-to-unit-production costs (DTUPC)

e. Temperature environment

f. Power considerations

2.2 FALSE ALARM RATE (FAR)

The NTEC Specification requires not more than one false hit per target system in 100 hours of field operation. This requirement is analyzed in Volume I and FAR rates established for the MILES systems. FAR and other important parameters derived from the system analysis are repeated in table 2-1. These criteria primarily affect the design of the detection system which is the heart of MILES.

2.3 WEAPON CHARACTERISTICS

A major constraint on system design was that the weapon characteristics be accurately simulated. Range, rate of fire, ammunition loads, hit/kill effects, and audio-visual cues are some of the more critical characteristics essential to realistic simulation.

Table 2-2 lists the weapons simulated and their characteristics. The laser transmitter design parameters of power, beam size and coding were selected to accomplish the simulation.

The restraints imposed by weapon characteristics simulation directly affect laser transmitter commonality and, in turn, DTUPC. For example, the multiplicity of range requirements forced noncommonality of the laser transmitters from the standpoint of laser power and beam spread. This is an area where extensive tradeoffs were performed comparing cost in terms of performance.

2.4 EYE SAFETY

Eye safety is governed by TB MED 279 criteria and was an overriding constraint on the laser output power and on the laser optics design. Table 2-3 shows the TB MED 279 eye safety limit criteria, eye safety information based on Letterman Army Institute of Research (LAIR) testing, and the XEOS laser parameters based on eye safety analysis.

TABLE 1-2

CRITICAL PARAMETER SUMMARY

Parameter	Condition	Minimum	Nominal	Maximum	
Noise Equivalent Radiant Exposure	Sunlight and signal on 5 of 6 detectors			0.49 μergs/cm^2	*
Threshold/Noise Ratio	Full sun	4.5 (TES) !	5.5	6.0	
Signal-to-Noise Ratio	(P_k = 90%)	7	7	11:1	
False Alarm Rate $\overline{FAR}$	MWLD-full sun CVLD-full sun			3.33 x 10^{-5}/hr 2.50 x 10^{-5}/hr	
Irradiance (minimum required)		1.3 μW/cm^2			
Peak Emission Wavelengths	-25°C to +62°C	8650Å	9100Å	9311Å	*
Detector Area		1 cm^2 (1 detector)		8 cm^2 (8 detectors)	
Shot Noise Bandwidth		100 kHz			
Amplifier/Detector Bandwidth for Signal Johnson Noise Bandwidth		500 kHz			*
Transmitter Power Output (with sun loading and barrel heating)	450M at 65°C 800M at 65°C 1000M at 65°C 2000M at 65°C 3000M at 65°C	0.3W 0.8W 0.9W 1.26W 1.55W	0.4W 0.9W 1.0W 1.5W 2.0W	0.5W 1.0W 1.2W 2.0W 2.5W	
Scintillation Signal Reduction	≥ 1000M 5 detectors	20%	35%	45%	
Optical Filter Sun Current Reduction	RG 830	70%	75%	80%	
Protective Cover Sun Current Reduction (Incremental Effect)	Optical filter already in place	17%	20%	23%	*
Optical Filter Laser Signal Reduction	RG 830 at 9040Å	10%	11%		
EMI Filter Signal Reduction		14%	16%		
Protective Cover Signal Reduction		9%	12%	14%	*
Code Weight		6	6	6	
Number of Word Repeats	Kill TES VES Near Miss TES VES		4 8 24 128		
Cosine and Off Axis Losses	45° off axis	30%	40%	50%	
Laser Transmitter	Present TB MED 279 Maximum Output Energy per Pulse = 0.32 erg			7.5 x 10^{-8} joules/cm^2	
	*Tentative LAIR eye safety conference ruling for MILES allows 5 ergs/pulse or 3.33 watts peak power output			*2.36 ergs/pulse *1.57 watts peak power	
ED Basline	4.5 ergs/pulse maximum				

TABLE 2-2

WEAPON CHARACTERISTICS

Weapons Simulated	Used by	Store Basic Load. (rounds)	Firing Rate (RPM)	Burst Limit (rounds)	Range of Simulator (Meters) Kill	Near Miss
<u>Short Range</u>						
M161A1 Rifle	Infantry	210	650	30	5/25 to 460	460
M60 Machine Gun	Infantry	600/1800	650	200	5/25 to 800	1100
Coax Machine Gun	Tanks	1800	650	200	5/25 to 800	1100
M2/M85 Machine Gun	Tanks	1200	650	200	5/25 to 800	1600
<u>Anti-Armor</u>						
Guns (Anti-tank)*:						
105 mm Gun	M60A1/A3 Tank	63	12		50/200 to 3000	3000
152 mm Gun	M60A2 and M551 AARV	33 and 20	6		50/200 to 2000	2000
<u>Missiles (Anti-tank)</u>						
Viper	Infantry	4	6		10 to 300	300
Dragon	Infantry	10	4		50/200 to 1000	1000
TOW	Infantry and Helicopter	10	4		50/200 to 3000	3000
Shillelagh	M60A2 and M551 AARV	13 and 9	4		800 to 3000	3000

*Defined to include "tank versus tank."

An eye safety analysis is included as Appendix A in Volume I. The analysis includes a report on the laser tests conducted by LAIR. Extensive analysis and design efforts were directed toward reducing the laser power required for the MILES systems.

TABLE 2-3

EYE SAFETY CRITERIA

	TB MED Criteria	LAIR Tests Eye Safe	XEOS Design Baseline Values
Short Range Laser Output Power	1.57W	3.33W	0.8W
Long Range Laser Output Power	1.57W	3.33W	3.0W
Pulsewidth			150 nsec.
Pulse Rate			3.0 KHz

2.5 DESIGN-TO-UNIT-PRODUCTION COST (DTUPC)

From the beginning of the first MILES Advanced Development (AD) program, DTUPC has been a major design constraint. The AD DTUPC goals expressed in June 1973 constant dollars are shown in table 2-4.

System cost as represented by DTUPC was a major design constraint throughout the program. No design decision was made without consideration of its impact upon the production unit costs. Cost tradeoffs were continually made to insure that DTUPC was minimized while at the same time the system performance criteria were met.

Since DTUPC was one of the first priority constraints on system design, tradeoffs were made whenever DTUPC goals were threatened. For example, the parts standardization program had a negative effect on DTUPC. The most cost effective approach was to use commercial components with the provision that the components and system satisfy the performance criteria of the specifications. Non-standard parts submittals were made for Government approval wherever DTUPC was a major factor in the decision. Table 2-5 is a December 1976 cost comparison of commercial components versus a MIL-SPEC equivalent. As can be noted from this abbreviated tradeoff chart, the MIL-SPEC standard components are three to five times the cost of the equivalent commercial component. DTUPC goals for the ED program and DTUPC estimates are included in Section 9.

TABLE 2-4

DTUPC GOALS

Devices	Production Quantity	DTUPC Goal June 1973
TES 17A30	20,000	$520
MGL 17A33	4,000	$525
VES 17A29	5,000	$810

TABLE 2-5

COST COMPARISONS

COMMERCIAL VERSUS MIL-SPEC COMPONENTS

Commercial Part No.	Unit Cost Commercial Part	Unit Cost MIL-SPEC 883 B Screening Equivalent Part
14006 CP	$ .80	$ 4.00
14007 CP	.20	1.06
14013 CP	.35	2.00
14015 CP	.70	4.00
14024 CP	.60	3.00
14040 CP	.60	3.00
14510 CP	.70	3.00
14528 CP	.80	4.00

Notes:

1. Parts are discrete electronic components used on ADM MILES.
2. Vendor quotation was from Motorola, Inc.
3. Prices quoted were budgetary and based on production quantities of 10,000 units per lot.
4. Prices are from August 1976 time period.

2.6 TEMPERATURE ENVIRONMENT

Temperature constraints were imposed by the ambient environment defined in the system specification and AR 70-38; "Research, Development, Test, and Evaluation of Material for Extreme Climate Conditions," 1 July 1969. The applicable environments are summarized in table 2-6.

Added to the ambient air temperature are the effects of both solar heating and weapon heating due to the firing of blanks. These added effects were analyzed and verified in blank firing thermal tests and the results are included as Appendix B.

Calculated simulator temperatures for a hypothetical firing sequence (see figure 2-1) show an increase of 45 degrees F in a period of 16 minutes with an expenditure of 100 rounds of blank ammunition. Figure 2-2 is a revised chart showing actual laser diode temperature with respect to time using three different firing rates for the weapon.

As the detail design progressed, the computer model developed for temperature determinations was refined and used to analytically verify the thermal design of the final configuration.

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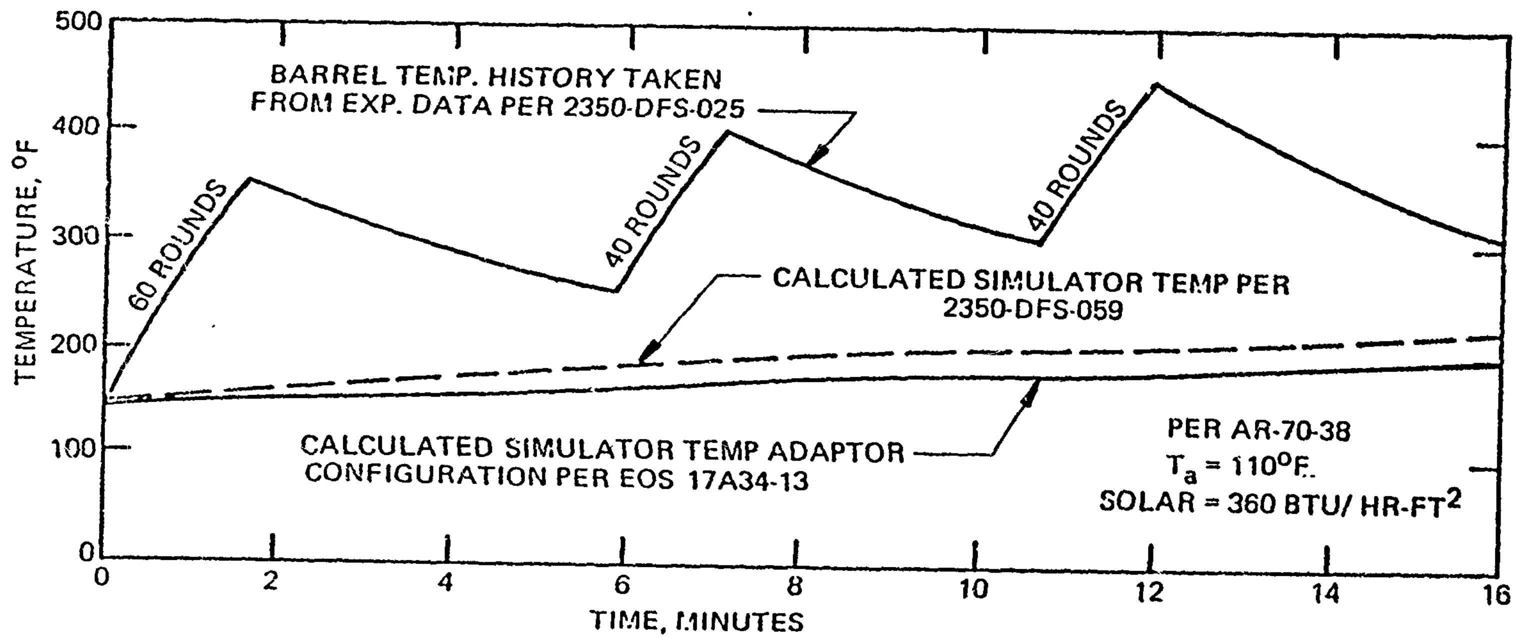

Figure 2-1. M16A1 Simulator Temperature History

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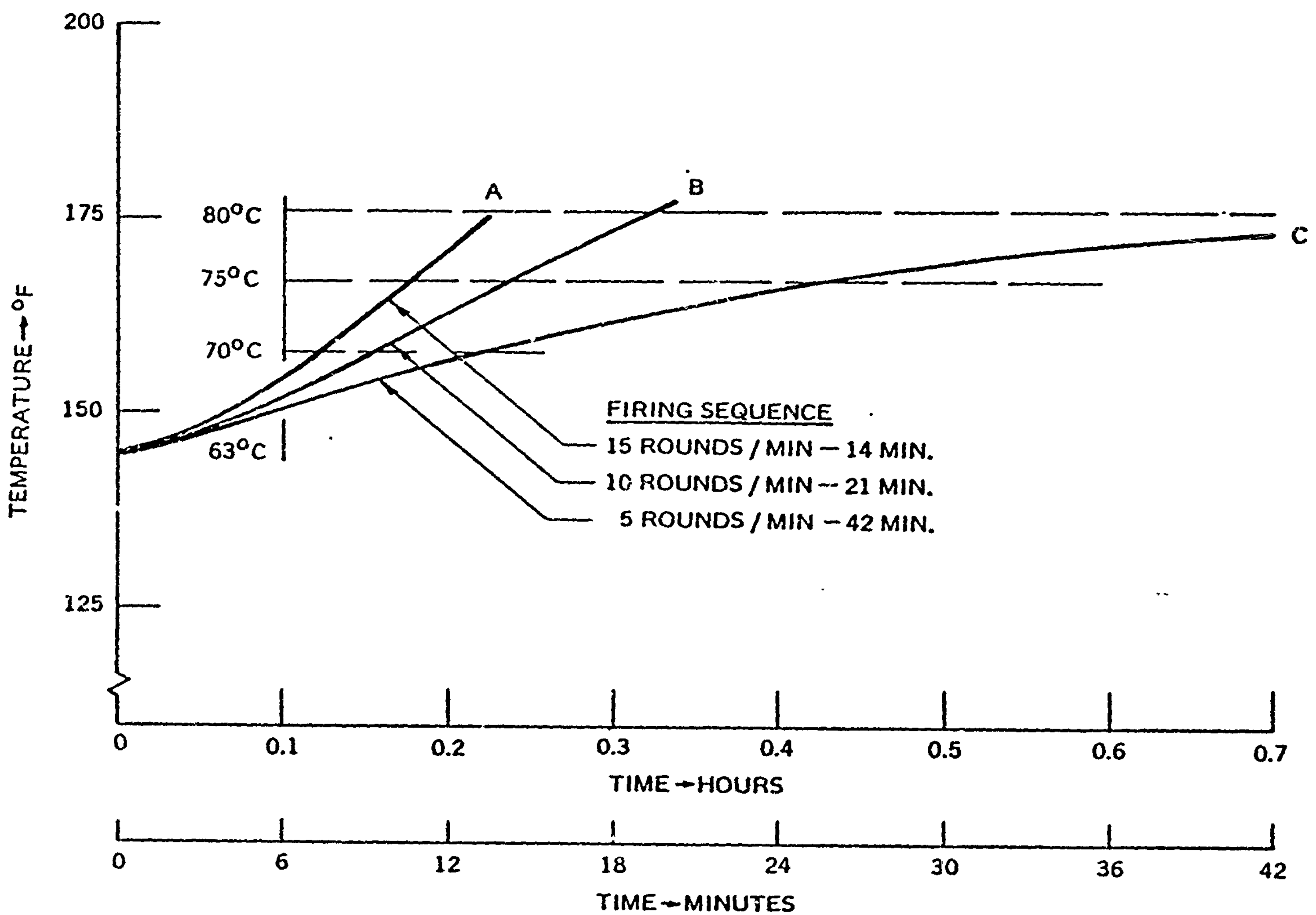

Figure 2-2. M16 Rifle Laser Diode Temperature While Firing 210 Rounds of Blank Ammunition Revised Computer Model (Per Actual Firing Data)

TABLE 2-6

MILES TEMPERATURE ENVIRONMENT SEQUENCE

Climatic	Operational Conditions			Storage and Transient Conditions	
	Ambient Air Temp. °F	Solar Radiation BTU/Hr-Ft	Ambient Rel. Hum. Percent	Induced Air Temp. °F	Induced Rel. Hum. Percent
5 Intermediate Hot-Dry	70 to 110	0 to 360	20 to 85	70 to 145	5 to 50
6 Intermediate Cold	-5 to -25	-	Tending Toward Saturation	-10 to -30	Tending Toward Saturation

2.7 POWER CONSIDERATIONS

The size, weight, and required battery lifetime of 100 hours for the M16A1 Rifle System limited the available power sources. Investigation and study resulted in the following battery choices:

Environment	Battery Selection
For Ambient Temperatures Above 26°F	Alkaline Battery Mallory P/N MN1604 (MIL-B-18D, P/N BA3090/U)
For Ambient Temperature Below 26°F	Lithium Organic Battery Mallory PCI (400-9) (MIL-B-18D, P/N BA5090/U)

The two batteries are physically interchangeable, the only differences between them being a greater lifetime at low temperature for the lithium organic battery (see figure 2-3). The physical configuration is shown in figure 2-4. Cost for the lithium organic battery is about three times that of the alkaline.

The Mallory MN1604 9V battery is rated for a service capacity of 500 milliamp hours (at 70°F temperature to 4.8 volts). Discharge curves for this battery are shown on figure 2-5.

Similarly, batteries for the vehicles were investigated resulting in the following selection for use in the CVKI:

Environment	Battery Selection
For Ambient Temperatures Above 26°F	Carbon Zinc Battery BA200
For Ambient Temperatures Below 26°F	Alkaline Battery BA3200

56050

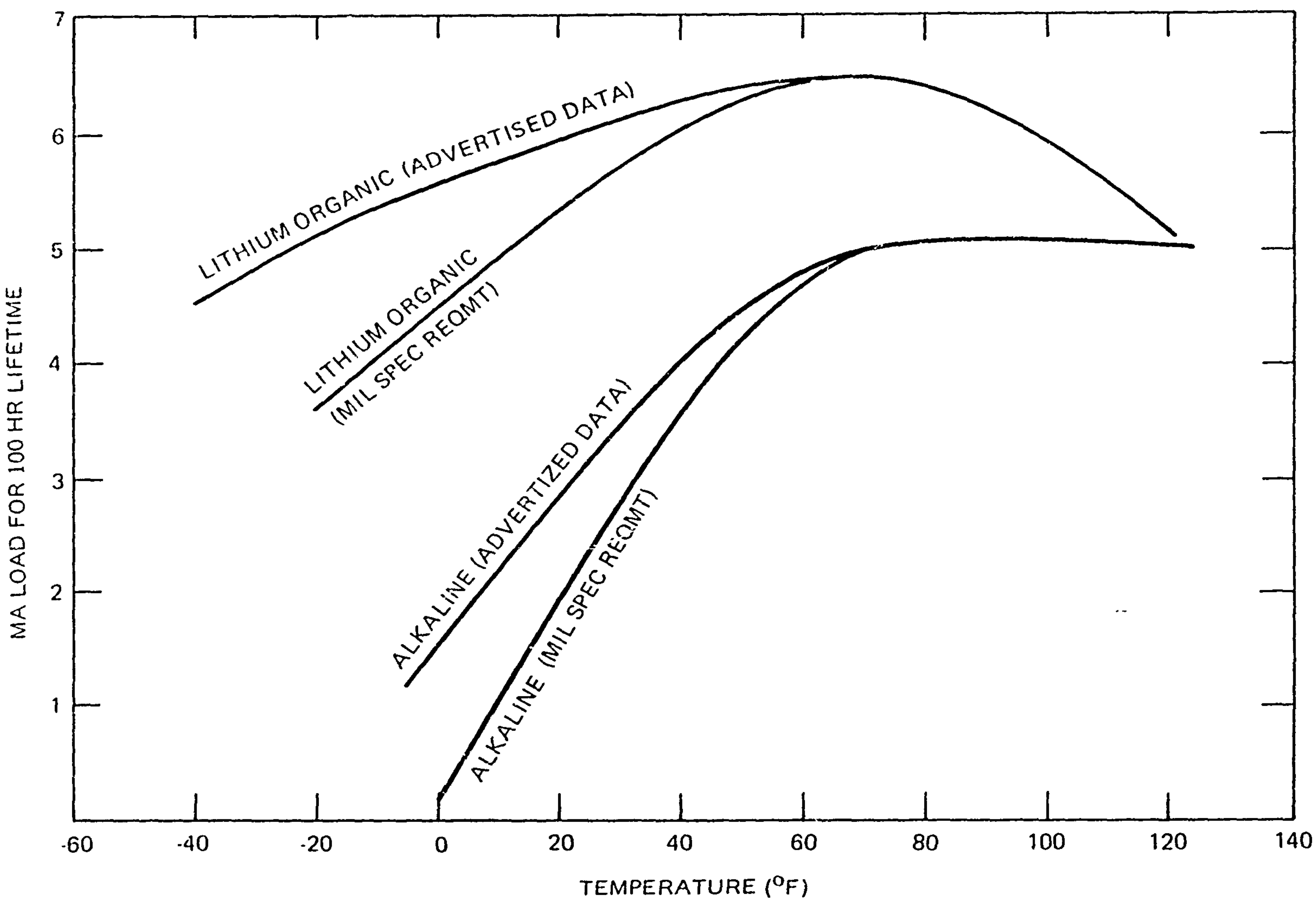

Figure 2-3. Battery Lifetime in Terms of Temperature

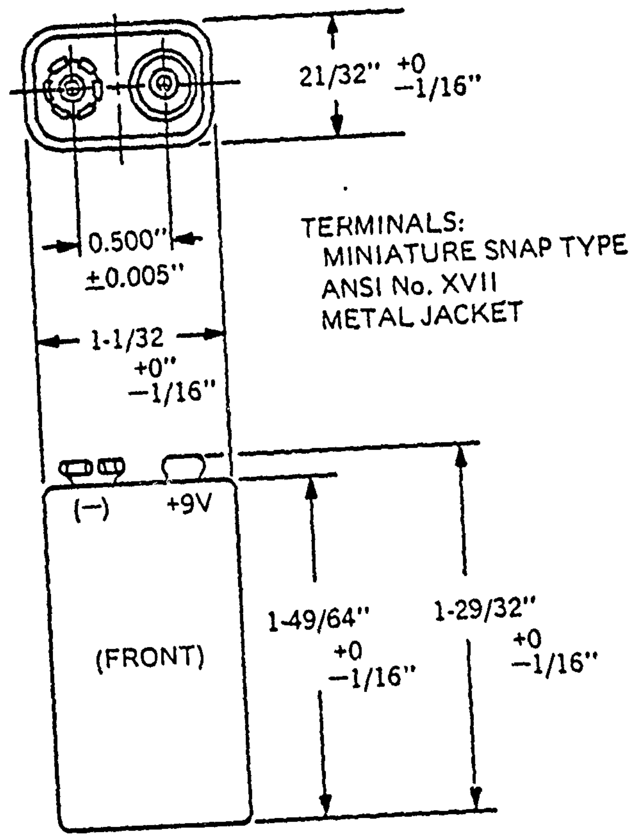

Figure 2-4. MILES 9-Volt Battery Configuration

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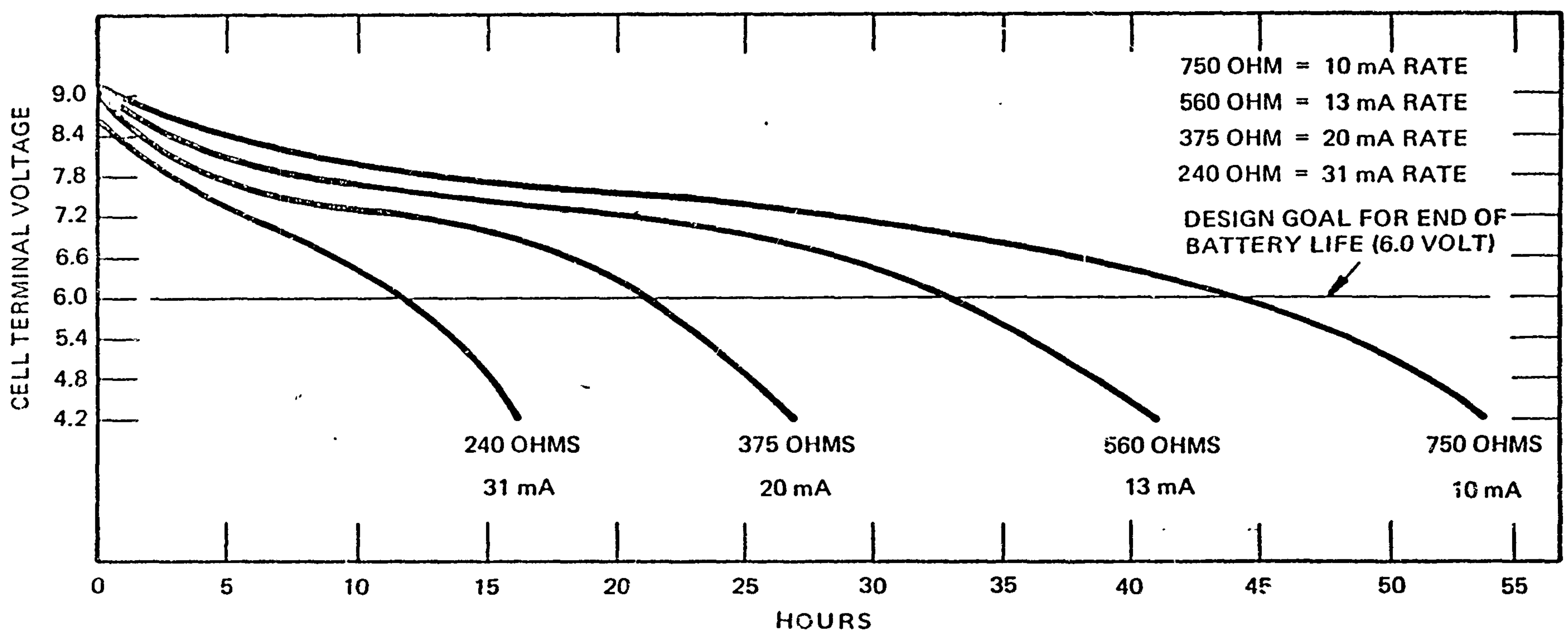

CELL TYPE: MN 1604
TEST CONDUCTED AT: 70°F
LOAD RESISTANCE: NOTED OHMS
REMARKS: RESISTANCE VALUES AND EQUIVALENT CURRENT DRAINS AT 7.5 VOLTS

Figure 2-5. Resistance Values and Equivalent Current Drains at 7.5 Volts

A maximum current drain of 2.5 ma per 9-volt battery in the system was established as a goal and was met. Typical current drain for MILES transmitters is 2.1 ma with surge currents to 20 ma. This load assures 100 hours life from alkaline batteries at all temperatures above 26 degrees F. All MILES electronic circuits are designed to operate at supply voltages of between 7.5 and 9 volts dc. Thus, battery life is defined as ending when battery voltage drops below 7.5 volts. Tables 2-7 and 2-8 show the current drain per battery for the MILES systems. It is obvious from the chart that the laser transmitters are within the design goal.

The CVKI exceeds the design goal and requires the use of vehicle power. Vehicle power is used only to power the vehicle hit/kill/miss strobe light.

Vehicle power, used only for the CVKI, is assumed to be defined by MIL-STD-1275 (AT, 14 July 1966, "Military Standard Electrical Circuit 28 Volt DC Transient Characteristics for Military Vehicles"). This specification indicates a nominal operating range from 26 to 30 volts with voltage swings from 15 to 40 volts. Ripple and spike specifications are also stated.

The addition of ATWESS to the MILES for use on TOW, DRAGON, and VIPER adds some drain to the MILES batteries. Surge current for firing the ATWESS is about 56 ma. Basic ammunition loads for the missiles are low. So, although ATWESS will reduce battery lifetime, it should not seriously degrade the total battery life under normal tactical training exercises.

TABLE 2-7

TES LASER TRANSMITTER CURRENT REQUIREMENTS

Encoder ROM	1.5 mA at 1%η 0.1 mA at 99%η	0.114 mA (idle mode)
Encoder Microprocessor	1.6 mA at 1%η 0.8 mA at 99%η	0.808 mA
Laser Driver		0.355 mA
Laser Driver Interface		0.275 mA
Total (Includes blank fire enable)		1.552 mA
Design Goal		2.5 mA

TABLE 2-8

BATTERY CURRENT DRAIN
(NOT INCLUDING ATWESS)

SYSTEM	ESTIMATED CURRENT DRAIN	ACTUAL PTM MEASUREMENT
MWLD		
Harness	1.81 mA	1.529 mA
Helmet	1.0 mA	0.954 mA
Laser Transmitter		
M16A1	1.55 mA	1.82 mA
M60 MG	1.55 mA	
M2 MG	1.55 mA	
M85 MG	1.55 mA	
DRAGON	1.55 mA	1.50 mA
VIPER	1.55 mA	
M60A1/A3		
Laser Transmitter - 105mm		
Laser Transmitter COAX.MG	18.79 mA	
CVLD		
CVKI		
M60A2/M551		
Laser Transmitter - 152 mm		
Laser Transmitter - COAX MG	18.75 mA	
CVLD		
CVKI		
APC - M2 MG		
Laser Transmitter - M2 MG	1.55 mA	
CVLD		
CVKI	17.25 mA	
INDEPENDENT TOW		
Laser Transmitter	1.55 mA	
Reveiver	1.81 mA	

*

SECTION 3

ELECTRONICS

The MILES electronic design represents a careful compromise between cost, performance, and reliability. Unit production cost was the driving consideration as outlined in subsection 3.1. The technologies chosen were as new as possible to avoid obsolescence in the MILES lifetime, but not so new as to run a risk of being proven inadequate and dropped from the marketplace during the MILES lifetime.

The electronics general design specifications were:

Temperature range:	-35 C to +65°C (no blank fire heating)
	-35 C to +85°C (blank fire heating)
Battery voltage:	6.8V to 9V (9V transistor battery)
	8V to 12V (12V lantern battery)

System performance, as tied to electronics design, is discussed in Volume I.

3.1 DTUPC

The following decisions were made based upon DTUPC considerations:

a. Automatic insertion of components in all high volume units dictated an inefficient board layout with component locations aligned. Thus, size was sacrificed in favor of cost.

b. Microprocessor implementation was chosen over a custom digital LSI circuit for all encoder applications. The cost advantage here lies in the high manufacturing volume inherent in the microprocessor product line. A microprocessor chip set is less expensive than a single very complex custom LSI. It is also much more flexible, a quality required due to the significant differences between weapon characteristics. A

single circuit board type performs all encoding functions for M16, M60, M85, and M2. Another single circuit board performs all encoding functions for the Viper and Dragon.

It should be noted that the MILES volume (about 30,000 units) is not high enough to justify most custom IC designs unless competing technologies are very expensive. The only case where a completely custom LSI was chosen was in the receiver decoder. In this case, microprocessors were unsuitable for the specialized task, and the task was well defined. The device could be used throughout the MILES system, and no commercial MSI circuits were available to do the task efficiently.

c. Semicustom LSI (Monochips by Interdesign) were chosen over custom linear ICs or standard operational amplifiers. Again, 90 percent of the Monochip fabrication process is identical for all Interdesign customers. Chip manufacturing overhead is geared to a high volume, thus yielding a lower unit cost than with a special MILES linear design. Standard operational amplifiers, on the other hand, do not simultaneously meet power, band-width, and noise requirements.

d. In many cases MIL-SPEC parts were too expensive and exceeded reliability requirements. Instead, non-MIL parts were procured with source control drawings (SCDs) which tailored reliability and testing requirements to the MILES system MTBF. Cost was thus significantly reduced and the system was designed to a specific failure rate.

The MILES system is represented by numerous electrical diagrams. The major ones are listed in table 3-1 and as needed referenced throughout this section in describing various circuit functions.

TABLE 3-1

MILES ELECTRICAL DIAGRAMS

Title	Drawing Number
Connection Diagram, Small Arms (M16)	11748949
Schematic Diagram	
Encoder - Small Arms	11749203-1
Laser Driver Interface Monochip	11748909
Laser Driver Monochip I	11748892
Modulator Dual Power	11749204-1
Laser	11749205-1
Connection Diagram, Small Arms (M85)	11748949
Schematic Diagram	
Encoder - Small Arms	11749203-4
Laser Driver Monochip I	11748892
Laser Driver Interface Monochip	11748909
Modulator Dual Power	11749204-2
Laser	11749205-2
Connection Diagram, Detector Belt, Seg. No. 2	11749242
Schematic Diagram	
Postamp/Signal Monochip Threshold Detector	11748921
Preamplifier Monochip	11748922
Detector Amplifier	11749314
Connection Diagram, Detector Belt, Seg. No. 3	11749303
Schematic Diagram	
Postamp/Signal Monochip Threshold Detector	11748921
Preamplifier Monochip	11748922
Detector Amplifier	11749314
Connection Diagram, Detector Belt, Seg. No. 4	11749299
Schematic Diagram	
Postamp/Signal Monochip Threshold Detector	11748921
Preamplifier Monochip	11748922
Detector Amplifier	11749314
Connection Diagram, Detector Belt, Seg. No. 5	11749295
Schematic Diagram	
Postamp/Signal Monochip Threshold Detector	11748921
Preamplifier Monochip	11748922
Detector Amplifier	11749314

TABLE 3-1 (Cont)

MILES ELECTRICAL DIAGRAMS

Title	Drawing Number
Connection Diagram, 152 mm (SHILLELAGH) XMTR	11748885
Schematic Diagrams	
Laser	11749205-3
Laser	11749205-2
Laser	11749368
Laser Driver Monochip I	11748892
SCR Driver Monochip I	11748968
Laser Driver Monochip I	11748892
105 mm, 152 mm, Coax Transmitter	11749308
152 mm WFS Transmitter	11749309
Connection Diagram, Controller Gun	11748967
Schematic Diagrams	
Laser	11749205-2
Modulator - Single Power	11749370
Controller Gun	11749327
Laser Driver Monochip I	11748892
Laser Driver Interface Monochip	11748909
Connection Diagram, TOW Simulator System	11835614 *
Schematic Diagrams	
Encoder TOW	11835587
Modulator	11749370
Laser Tube	11749205-5
Decoder - TOW	11835590
Amplifier	11749314
Reticle Control	11835812
MCS	11835595
Tube Assembly	11749619
AIWESS	11749687
Connection Diagrams, Tracker Assembly	11748952
Schematic Diagram	
Laser	11749205-3
Laser Driver Interface Monochip	11748909
Laser Driver Monochip I	11748892
Modulator - Single Power	11749370
Encoder - Dragon	11749311
Connection Diagram, Detector Belt, Seg. No. 1	11749241
Schematic Diagram	
Postamp/Signal Monochip Threshold Detector	11748921
Detector Amplifier	11749314
Preamplifier Monochip	11748922

TABLE 3-1 (Cont)

MILES ELECTRICAL DIAGRAMS

Title	Drawing Number
Connection Diagram for CVKI	11748993
Schematic Diagrams	
CVKI Electronics Board	11749376
CIA Console	(11749448)
Schematic Diagrams	
CVKI Interface	11749386
Microprocessor	11749345
Logic Diagrams	
Multi-Digit Display, 7 Segment	11749497
Weapon ID	11749427
Decoder	11749343
LCA Console	(11749396)
Schematic Diagrams	
CVKI Interface	11749386
Microprocessor	11749345
Trigger Interface	11749341
Logic Diagrams	
Multi-Digit Display, 7 Segment	11749497
Weapon ID and Display	11749344
Decoder	11749343
Transmitter Interface	11749342
Connection Diagram, Small Arms (M2)	11748949
Schematic Diagrams	
Encoder - Small Arms	11749203-3
Laser Driver Monochip I	11748892
Laser Driver Interface Monochip	11748909
Modulator Dual Power	11749204-2
Laser	11749[illegible]05-2

TABLE 3-1 (Cont)

MILES ELECTRICAL DIAGRAMS

Title	Drawing Number
Connection Diagram, VIPER Assembly	11748951
Schematic Diagram	
Encoder - VIPER	11749312
Laser Driver Monochip I	11748892
Laser Driver Interface Monochip	11748909
Modulator Dual Power	11749204-2
Laser	11749205-2
Connection Diagram, 105 mm/COAX XMTR	11748884
Schematic Diagram	
Laser	11749205-2
105 mm, 152 mm, COAX Transmitter	11749308
Connection Diagram, Small Arms (M60)	11748949
Schematic Diagram	
Encoder - Small Arms	11749203-2
Modulator Dual Power	11749204-2
Laser	11749205-2
Laser Driver Monochip I	11748892
Laser Driver Interface Monochip	11748909
Connection Diagram, Helmet	11748891
Connection Diagram, MWLD Harness	11748857
Schematic Diagram	
Detector Amplifier	11749314
Preamplifier Monochip	11748922
Postamp/Signal Monochip Threshold Detecotr	11748921
MWLD Harness	11749315
Helmet MWLD	11749313

3.2 PROGRAMMING THE UNITS WITH JUMPER STRAPS

3.2.1 LCA WEAPONS

3.2.1.1 LCA Loaders Box Weapon Selection

a. The LCA loaders box has the capability of controlling zero to three weapons, dependent upon the type of vehicle.

b. The LCA loaders box has the capability of accommodating three different types of weapons (total amount equals 31).

(1) Missile weapons (4) (refer to table 3-2)

(2) Heavy slow rate weapons (15) (refer to table 3-3)

(3) Automatic rapid fire weapons (12) (refer to table 3-4)

c. Four possible combinations can be accommodated in a three-weapon vehicle setup:

(1) Automatic, heavy, missile (example: M551 tank)

(2) Automatic, heavy, automatic

(3) Automatic, automatic, missile

(4) Automatic, automatic, automatic

d. Four possible combinations can be accommodated in a two-weapon vehicle setup:

(1) Automatic, heavy (example: M60A1 tank)

(2) Automatic, missile

(3) Automatic, automatic

(4) Heavy, missile

e. For a one-weapon setup:

(1) Automatic

(2) Heavy

(3) Missile

3.2.1.2 LCA Loaders Box Weapon Setup

a. Weapon 1 - automatic rapid fire weapon with or without blank fire. The rate of fire is dependent upon the number of hit and miss words per round.

TABLE 3-2

MILES WEAPON SIMULATION MISSILES

Weapon	Basic Load (Actual)	Basic Load MILES	Firing Rate (Actual)	Firing Rate MILES	Code Hit/NM	Source
Hellfire	16	16	4	4	2	Estimate
TOW*	12	12	4	4	7	Specification *
Shillelagh	9	9	4	4	7	Specification
Sagger	4	4	4	4	3	Estimate
Dragon*	4	4	4	4	8	Specification

*Independent weapon transmitter

TABLE 3-3

MILES WEAPON SIMULATION SLOW FIRE WEAPONS

Weapon	Basic Load (Actual)	Basic Load MILES	Firing Rate (Actual)	Firing Rate MILES	Code Hit/NM	Source
60 mm	75	75	30	30	4/28	Estimate
81 mm	114	99	12	12	4/28	Estimate
4.2 inch	88	88	10	10	4/28	Estimate
2.75 inch Rocket (4 pods)	76	76		116	14/28	Army Ref. Guide
105 mm (XMI)	60	60	12	12	12/28	Estimate
105 mm	63	63	12	12	12/28	Specification
90 mm M48	60	60		12	17/28	Jane's Page 356
120 mm English	53	53		12	16/28	Jane's Page 346
120 mm (XMI)	50	50		12	16/28	Estimate
152 mm (M551	20	20	6	6	13/28	Specification
8" Howitzer		99	0.5	2	13/28	Jane's Page 412
105 mm Howitzer		99	3	3	13/28	Jane's Page 419
Maverick		4		2	1/28	Estimate
Chaparral	12	12	6	4	25/28	MILES Task III Rep.
40 mm Grenade Launcher	300	99	400	100	19/29	Army Ref. Guide
Viper*	4	4	6	6	15/28	Specification

*[illegible]

TABLE 3-4

MILES WEAPON SIMULATION RAPID FIRE WEAPONS

Weapon	Basic Load (Actual)	Basic Load MILES	Firing Rate (Actual)	Firing Rate MILES	Code Hit/NM	Source
Coax (7.62 mm)	1800	1800	650	682	27/29	Specification
Coax (7.62 mm)	4900	4900	650	682		Estimate
Coax (7.62 mm)		9900		750		Estimate
Minigun, 7.62 mm M27E1 Helo	2000	2000	2000	2045	27/29	Army Ref. Guide
Bushmaster (25 mm)	900	900	750	744	25/29	Army Ref. Guide
Vulcan 20 mm	1100	1100	1000	1023	23/29	Jane's Page 100
Vulcan 20 mm	1100	1100	3000	3273	23/29	Jane's Page 100
Vulcan 20 mm (Airborne)	1200	1200	6000	5455	23/29	Jane's Page 519
ZU23-4		1800	4000	4090	22/29	Jane's Page 101
GAU-8 30 mm	1350	1400	2000	2045	21/28	Jane's Page 518
GAU-8 30 mm	1350	1400	4000	4090	21/28	Jane's Page 518
XM-188 (AH) 30 mm	600	600	2000	2045	21/28	Jane's Page 521
M16A1*	210	210	650	682	27/29	Specification
M2 Machine Gun*	600	600	650	682	24/29	Specification
M85 Machine Gun*	1200	1200	650	682	24/29	Specification
M60 Machine Gun*	1200	1200	650	682	27/29	Specification

*Independent weapon transmitter

Six variables and two fixed constants are required for Weapon 1.

Variables

(1) Number of belts (selection - 0 through 99)

(2) Rounds per belt (selection - 0 through 255)

(3) Hit code (110 _ _ _ _ _ _ _ _ _)

(4) Hit words per round (selection - 0 through 255)

(5) Miss code (110 _ _ _ _ _ _ _ _ _)

(6) Miss words per round (selection - 0 through 255)

Fixed Constants

(1) Hit load/fire encode (to select the proper load capacitor and laser

(2) Miss load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 1: coax 7.62 mm machine gun

b. Weapon 2 - heavy slow rate weapon with 128 man hit words inserted between the heavy weapon hit and miss word messages OR automatic rapid fire weapon without blank fire (variables and fixed constants same as Weapon 1).

Six variables and five fixed constants are required for Weapon 2.

Variables

(1) Number of heavy weapon rounds (selection - 0 through 99)

(2) Rate of fire (selection - 2 through 120 rpm)

(3) Heavy weapon hit code (110 _ _ _ _ _ _ _ _ _)

(4) Hit words per round (selection - 0 through 255)

(5) Heavy weapon miss code (110 _ _ _ _ _ _ _ _ _)

(6) Miss words per round (selection - 0 through 255)

Fixed Constants

(1) Heavy weapon hit load/fire encode (to select the proper load capacitor and laser)

(2) Man hit words per round (128)

(3) Man hit code (11001000111, code number 27)

(4) Man hit load/fire encode (to select the proper load capacitor and laser)

(5) Heavy weapon miss load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 2 (heavy weapon): 152 mm main gun

c. Weapon 3 - missile weapon with 128 man hit words following after the fixed 10.24 second missile track sequence period OR automatic rapid fire weapon without blank fire (variables and fixed constants same as Weapon 1). Two variables and six fixed constants are required for Weapon 3 as a missile weapon.

Variables

(1) Number of missile rounds (selection - 0 through 99)

(2) Missile hit code (110 _ _ _ _ _ _ _ _ _)

Fixed Constants

(1) Number of missile words per message (8)

(2) Number of missile messages per round (32):

2 per second for first 8 seconds

8 per second for last 2 seconds

(3) Missile hit load/fire encode (to select the proper load capacitor and laser)

(4) Man hit words per round (128)

(5) Man hit code (11001000111, code number #27)

(6) Man hit load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 3 (missile weapon): Shillelagh

The selection of the weapons is accomplished by programming jumpers in the cable mating with connector J3 of the LCA unit (refer to table 3-5).

3.2.2 LCA LOADERS BOX VEHICLE SETUP

a. The LCA loaders box can be configured into 4 different vehicle configurations.

(1) Tank (example: M60A1 tank)

(2) APC (example: M13 APC)

(3) Aircraft/helicopter for future MILES

(4) Truck/jeep for future MILES

b. Each vehicle configuration has separate kill probabilities for weapon hit reception.

TABLE 3-5. VEHICLE - WEAPON SELECTION

	WEAPON 1[1] CONNECTOR J3[2,7] Pins					WEAPON 2 CONNECTOR J3[2,7] Pins						WEAPON 3 CONNECTOR J3[2,7] Pins					
WEAPON	a	F	b	G	c	H	J	K	d	L	r	M	f	N	P	g	R
Hellfire[3]	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
TOW[3]	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	1
Shillelagh[3]	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	1	0
Sagger[3]	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	1	1
60mm[4]	-	-	-	-	-	0	0	0	1	0	0	-	-	-	-	-	-
81mm[4]	-	-	-	-	-	0	0	0	1	0	1	-	-	-	-	-	-
4,2 inch[4]	-	-	-	-	-	0	0	0	1	1	0	-	-	-	-	-	-
2.75" Rocket[4]	-	-	-	-	-	0	0	0	1	1	1	-	-	-	-	-	-
105mm (XM1)[4]	-	-	-	-	-	0	0	1	0	0	0	-	-	-	-	-	-
90mm[4]	-	-	-	-	-	0	0	1	0	0	1	-	-	-	-	-	-
105mm[4]	-	-	-	-	-	0	0	1	0	1	0	-	-	-	-	-	-
120mm English[4]	-	-	-	-	-	0	0	1	0	1	1	-	-	-	-	-	-
152mm[4]	-	-	-	-	-	0	0	1	1	0	0	-	-	-	-	-	-
120mm (XM1)[4]	-	-	-	-	-	0	0	1	1	0	1	-	-	-	-	-	-
8 inch[4]	-	-	-	-	-	0	0	1	1	1	0	-	-	-	-	-	-
105mm Howitzer[4]	-	-	-	-	-	0	0	1	1	1	1	-	-	-	-	-	-
Maverick[4]	-	-	-	-	-	0	1	0	0	0	0	-	-	-	-	-	-
Chapparral[4]	-	-	-	-	-	0	1	0	0	0	1	-	-	-	-	-	-
Grenade (40mm)[4]	-	-	-	-	-	0	1	0	0	1	0	-	-	-	-	-	-

TABLE 3-5. VEHICLE - WEAPON SELECTION (Cont.)

WEAPON	a	F	b	G	c	H	J	K	d	L	r	M	f	N	P	g	R
			WEAPON 1[1] CONNECTOR J3[2,7] Pins					WEAPON 2 CONNECTOR J3[2,7] Pins							WEAPON 3 CONNECTOR J3[2,7] Pins		
Coax (1800 Rnds) (7.62mm)[5]	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1
7.62mm (4900 Rnds)[5]	1	0	1	0	0	1	1	0	1	0	0	1	1	0	1	0	0
7.62mm (9900 Rnds)[5]	1	0	1	0	1	1	1	0	1	0	1	1	1	0	1	0	1
7.62mm mini-gun (2000 rpm)[5]	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
Bushmaster	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1
20mm Vulcan (1000 rpm)[5]	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0
20mm Vulcan (3100 rpm)[5]	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1
20mm Vulcan (5400 rpm)[5]	1	1	0	1	0	1	1	1	0	1	0	1	1	1	0	1	0
23mm, Zu23-4[5]	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	1
30mm GAU-8 (2000 rpm)[5]	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0
30mm GAU-8 (4000 rpm)[5]	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1
30mm(AH) XM-188[5]	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0
Dummy[6]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

NOTES:

1 Blank fire or dry fire selected at connector J1.

2 0 = Ground = Logic Level 0
1 = V_{dd} = Logic Level 1

3 Missiles can be simulated only in Weapon 3 position

4 Slow firing weapons can be simulated only in Weapon 2 position

5 Rapid fire weapons can be simulated in all Weapon positions

6 No Weapon Selected

7. Reference - Connector J3, 11749505

The selection of the vehicle type is accomplished by cable programming on connector J3 of the LCA unit. Refer to table 3-6.

TABLE 3-6

LCA VEHICLE TYPE

Connector J3

Vehicle Type	Vehicle ID 2 Pin D	Vehicle ID 1 Pin E
Tank	1	1
APC	1	0
AC/Helo	0	1
Jeep/Truck	0	0

Note: 0 = Ground = Logic Level 0
1 = VDD = Logic Level 1

3.2.3 LCA COAX BLANK FIRE

Automatic rapid fire weapons used as Weapon 1, listed in table 3-2 have the option of operating in either the dry fire mode where the trigger activation initiates the fire sequence or the blank fire enable mode where the audio from the blank fire ammunition initiates the fire sequence. The selection of either dry fire or blank fire enable mode is accomplished by using either the dry fire adapter or blank fire adapter.

3.2.4 CIA VEHICLE TYPE

The CIA has the capability of simulating the vulnerability of four different vehicle types, but does not simulate weapons. The four different types of vehicles are:

a. Tank

b. APC (example: M113)

c. Aircraft/Helicopter

d. Jeep/Truck

The selection of the vehicle type is accomplished by cable programming on J1 of the CIA unit. Refer to table 3-7.

TABLE 3-7

CIA VEHICLE TYPE

Vehicle Type	Vehicle ID 2 Pin D	Vehicle ID 1 Pin E
Tank	1	1
APC	1	0
Aircraft/Helo	0	1
Jeep/Truck	0	0

Note: 0 = Ground = Logic Level 0
1 = VDD = Logic Level 1

3.2.5 SMALL ARMS TRANSMITTER

The small arms transmitter (TES Encoder) is designed such that the encoder electronics printed circuit board and TES Encoder Software in the ROM can be used in the following weapons:

a. M16 Rifle

b. M60 Machine Gun

c. M2 Machine Gun

d. M85 Machine Gun

The selection of one of the four weapons is accomplished by jumper wires on the encoder electronics printed circuit board. Refer to figure 3-1, Note 4.

3.2.6 VIPER/DRAGON/TOW ENCODER BOARDS

The Viper/Dragon/TOW Software (in a ROM) is designed to be utilized for the Viper, Dragon, and TOW weapons. The Viper, Dragon, and TOW encoder electronics are very similar, the exceptions being (1) the Viper transmits two levels of laser power whereas the Dragon and TOW transmit only one level of laser power, (2) the Dragon requires a weapon key signal whereas the Viper and TOW do not. These differences are incorporated in the different encoder printed circuit boards for the three weapons. The selection of the three weapons is accomplished by two weapon ID bits which are monitored by the 1802 microprocessor on two of its external flag inputs (EF3* and EF4*).

Viper encoder printed circuit board (refer to figure 3-2)
Dragon encoder printed circuit board (refer to figure 3-3)
TOW encoder printed circuit board (refer to figure 3-4)

No jumpers are required to perform the selection, because the circuit boards are different for the three weapons.

3.3 POWER-ON-RESET (POR)

The MILES devices use both random and programmable logic in a variety of ways. In most cases, it is necessary to ensure that the logic circuitry be reset to a specific state at the time power is connected so that subsequent processing of signals may proceed in the expected way. This feature is provided by the POR circuitry. The basic requirements of a POR circuit are as follows:

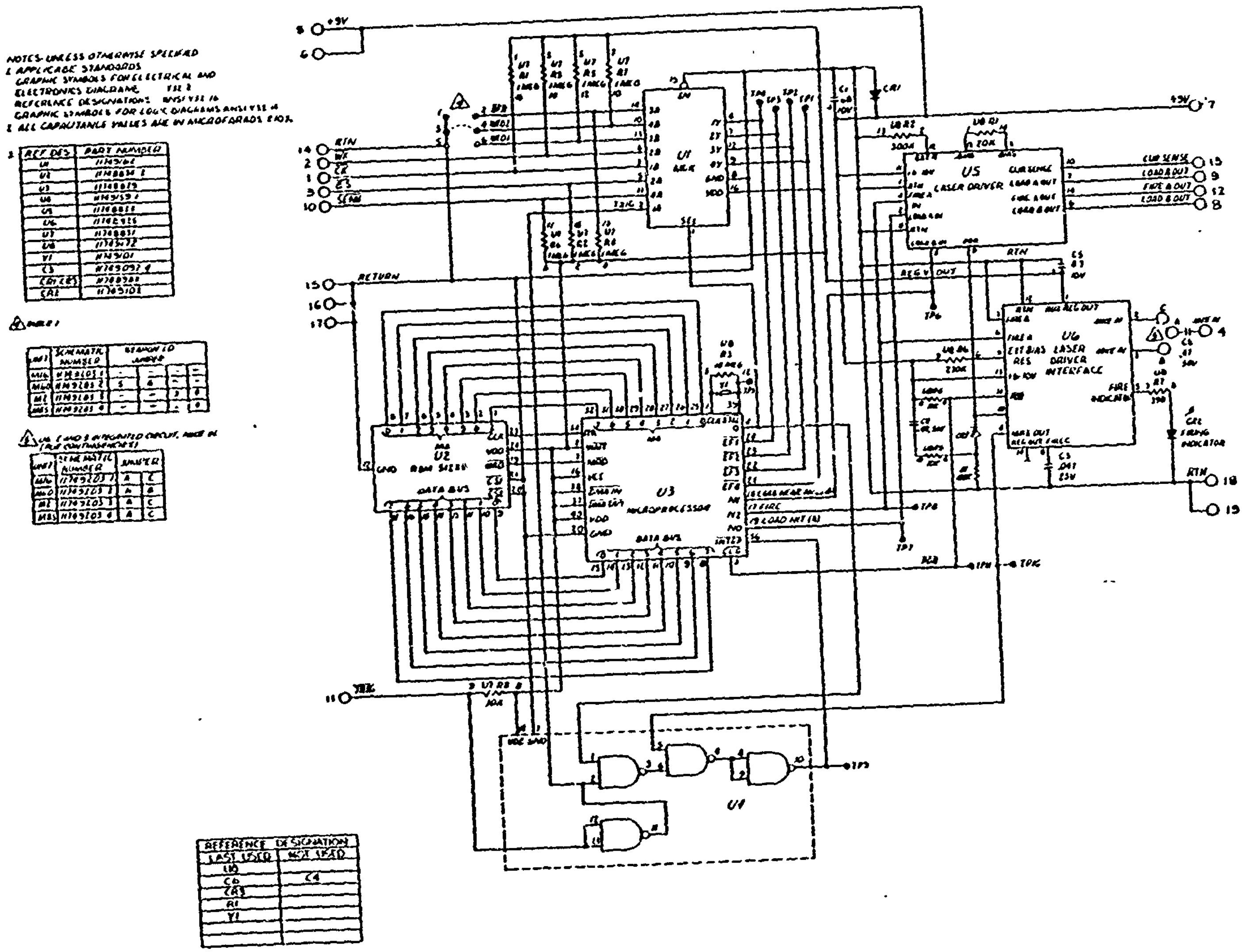

Figure 3-1. Small Arms Encoder Schematic Diagram

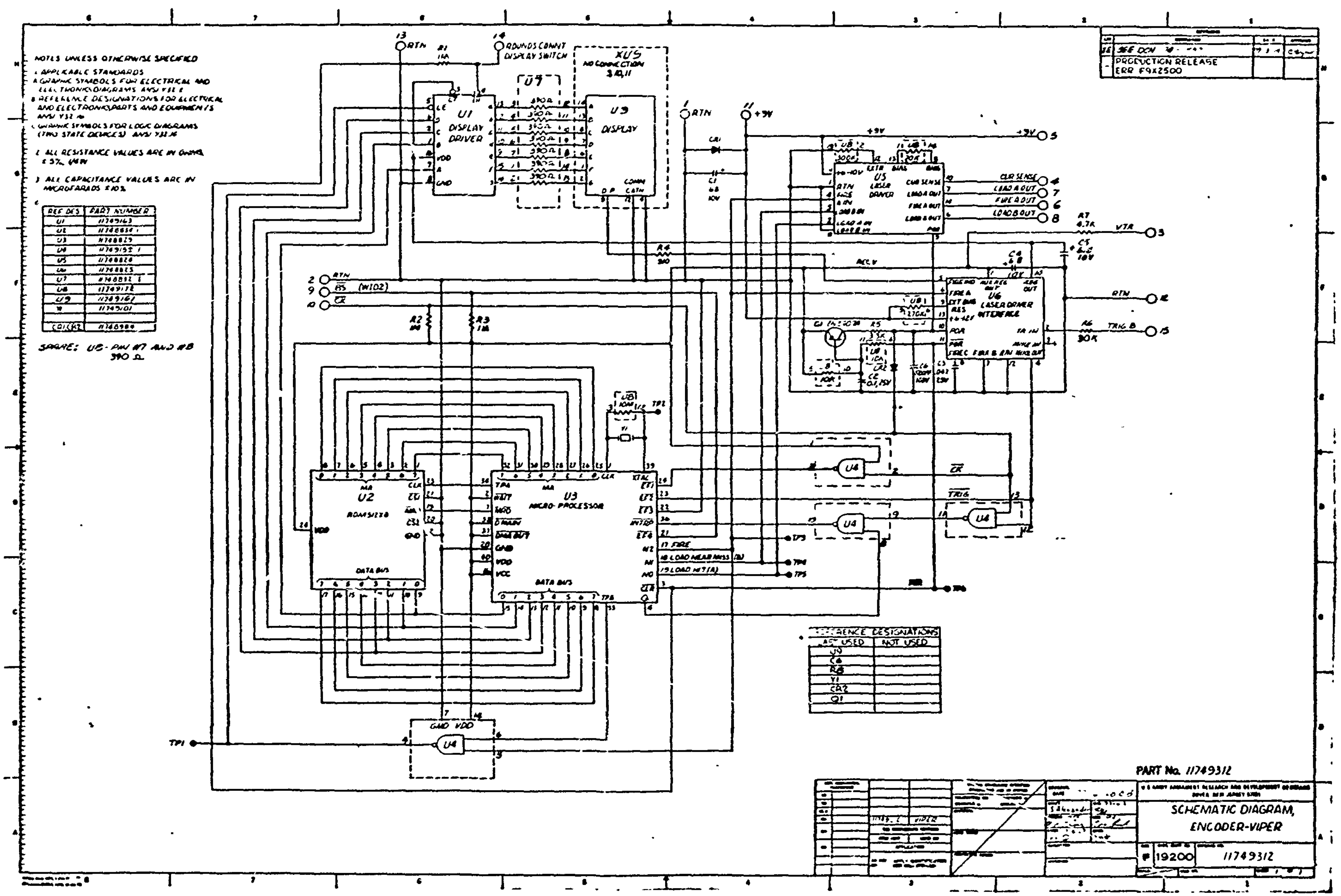

Figure 3-2. VIPER Encoder Schematic Diagram

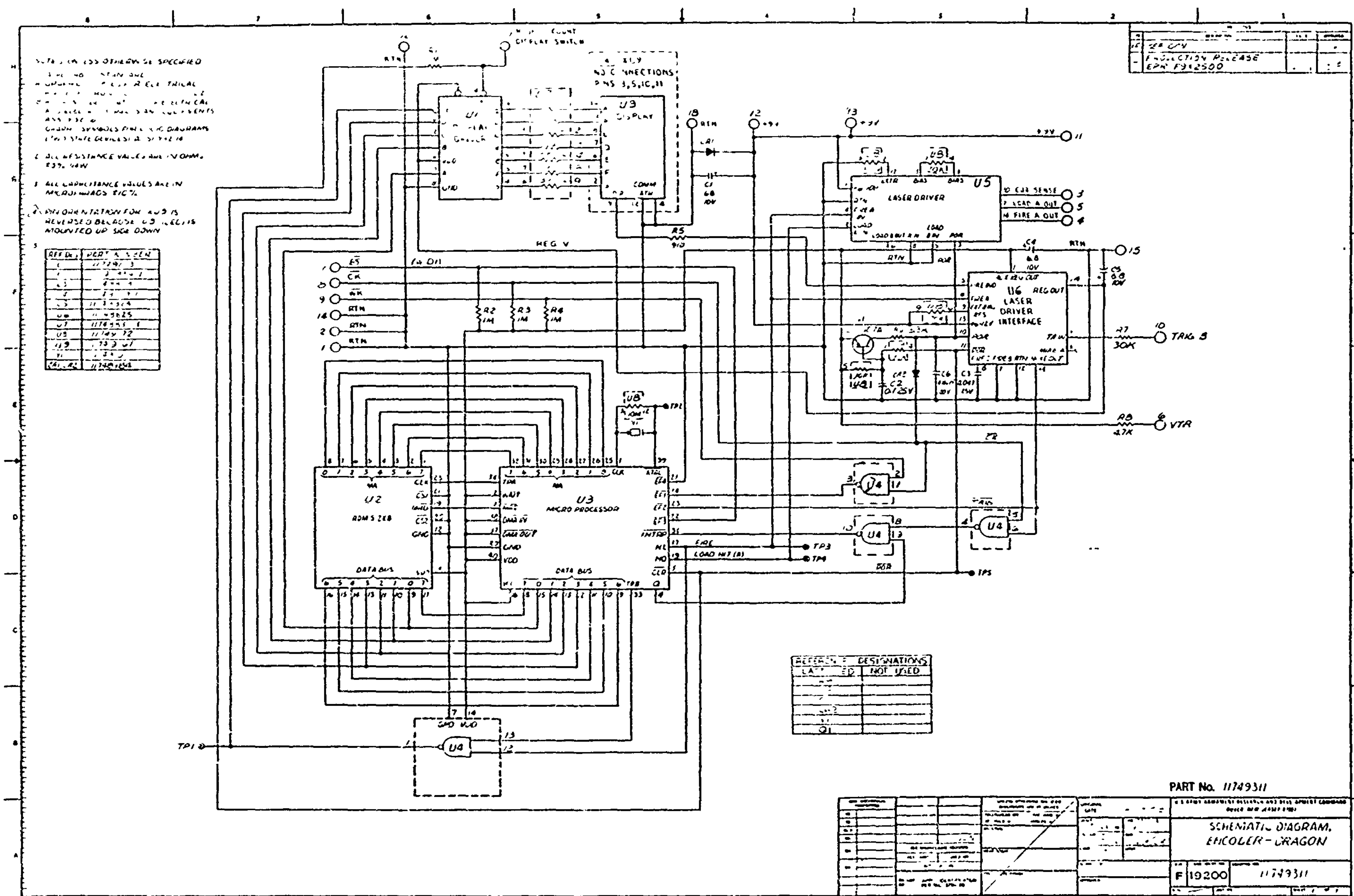

Figure 3-3. DRAGON F ler Schematic Diagram

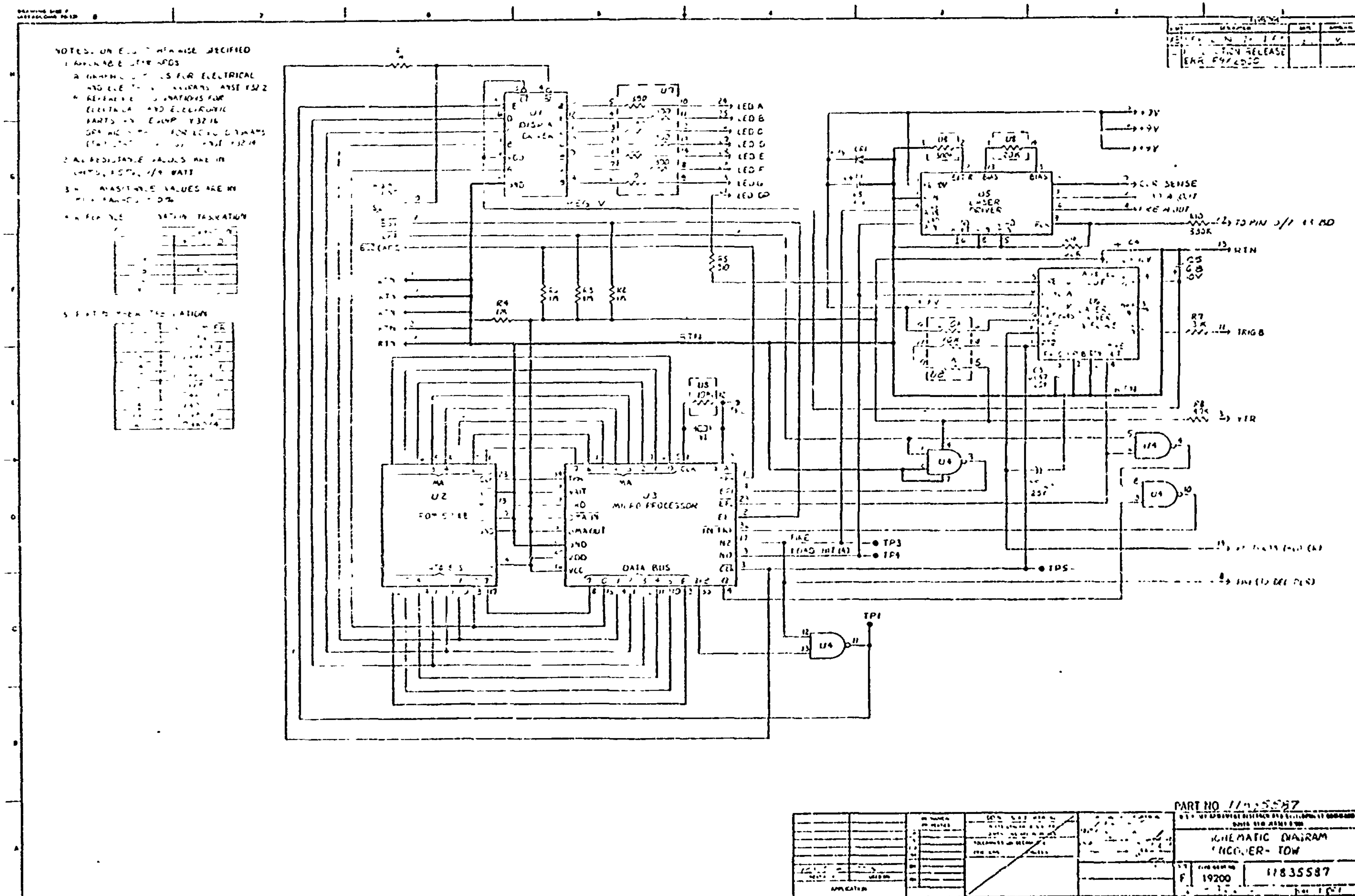

Figure 3-4. TOW Coder Schematic Diagram

a. It must provide a reset signal of the desired polarity.

b. The signal must persist long enough after power is applied to permit other functions such as the crystal clock oscillator to start properly.

c. The rise or fall time at the end of the POR signal must be fast enough to avoid logic problems.

d. The reset time of the POR circuit itself must be reasonably short. Thus, if power is first applied and then for some reason is removed and re-applied, the waiting period before the second application of power to guarantee a successful POR must not be inconveniently long.

In the MILES system, the active portion of the POR circuitry is part of a specialized large scale integrated circuit (LSI). This circuit, together with some external components, generates the logic pulse required by the microprocessor and associated logic. The pulse produced for this purpose must remain low after power application for about 15 milliseconds after which there must be a fast transition in about 500 nsec to a high logic level. Because the required POR pulse is low during the reset interval, it is properly called $\overline{\text{POR}}$.

The positive POR signal is also used in the independent MILES transmitters such as the M16A1 rifle, the machine guns and the Viper, Dragon, and TOW. In these cases a brief positive pulse is required by the Laser Driver circuitry to ensure that an erroneous "load" command for the laser does not occur at power turn-on but awaits the appropriate signal from the microprocessor. Careful pulse shaping is not required in this case.

A typical POR application in MILES occurs in the Encoder - Small Arms, figure 3-1. Here U6 is the specialized LSI, part of which is used to generate $\overline{\text{POR}}$. This reset signal is fed to the microprocessor "clear" input to perform the necessary reset function at power turn-on. POR is fed to U5, the laser driver circuit, to insure re-setting the load flip flops so that load signals for the laser will only be generated in accordance with the proper commands from the microprocessor.

To understand the function of the POR generating circuit, reference is made to figure 3-5 where the pertinent section of figure 3-1 is reproduced together with the significant portion of U6.

It will be seen that when the battery is first connected, C2 is initially discharged. Current to charge C2 must flow through the series 10K resistor, U8-R5, and through the parallel combination of R1 and CR3 and the base of Q1 within U6. As a result Q1 is turned on, which turns Q29 and Q30 off and Q31 on. This causes the collector of Q31 to saturate, producing a low-voltage at pin 11 ($\overline{POR}$). This low voltage persists until the charging current for C2 gradually diminishes at which point Q1 begins to turn off. As the collector voltage of Q1 begins to rise,Q29 and Q30 begin to turn on. Q29 shunts current from the base of Q1, greatly accelerating the rate at which Q1 turns off. The end result is that Q31 turns off quite rapidly producing a fast, well-defined trailing edge to the $\overline{POR}$ pulse.

The voltage appearing at pin 10 of U6 is somewhat greater than one base emitter drop at the moment the battery is connected. This signal, called POR, is fed to the bases of a pair of transistors within U5 which serve to re-set the two "load" flip-flops thereby avoiding false load signals.

Thus, we have described the generation of the two pulses, POR and $\overline{POR}$. There remains a description of the situation when power is removed. At this time, C2 is charged to battery voltage. With the battery removed, C2 discharges through the series combination of U8-R5 and R1 and the remainder of the encoder circuitry which completes the discharge circuit. At the beginning of the discharge period, the encoder circuitry looks like about 5000 ohms but this equivalent resistance gradually rises as the voltage drops until it eventually reaches

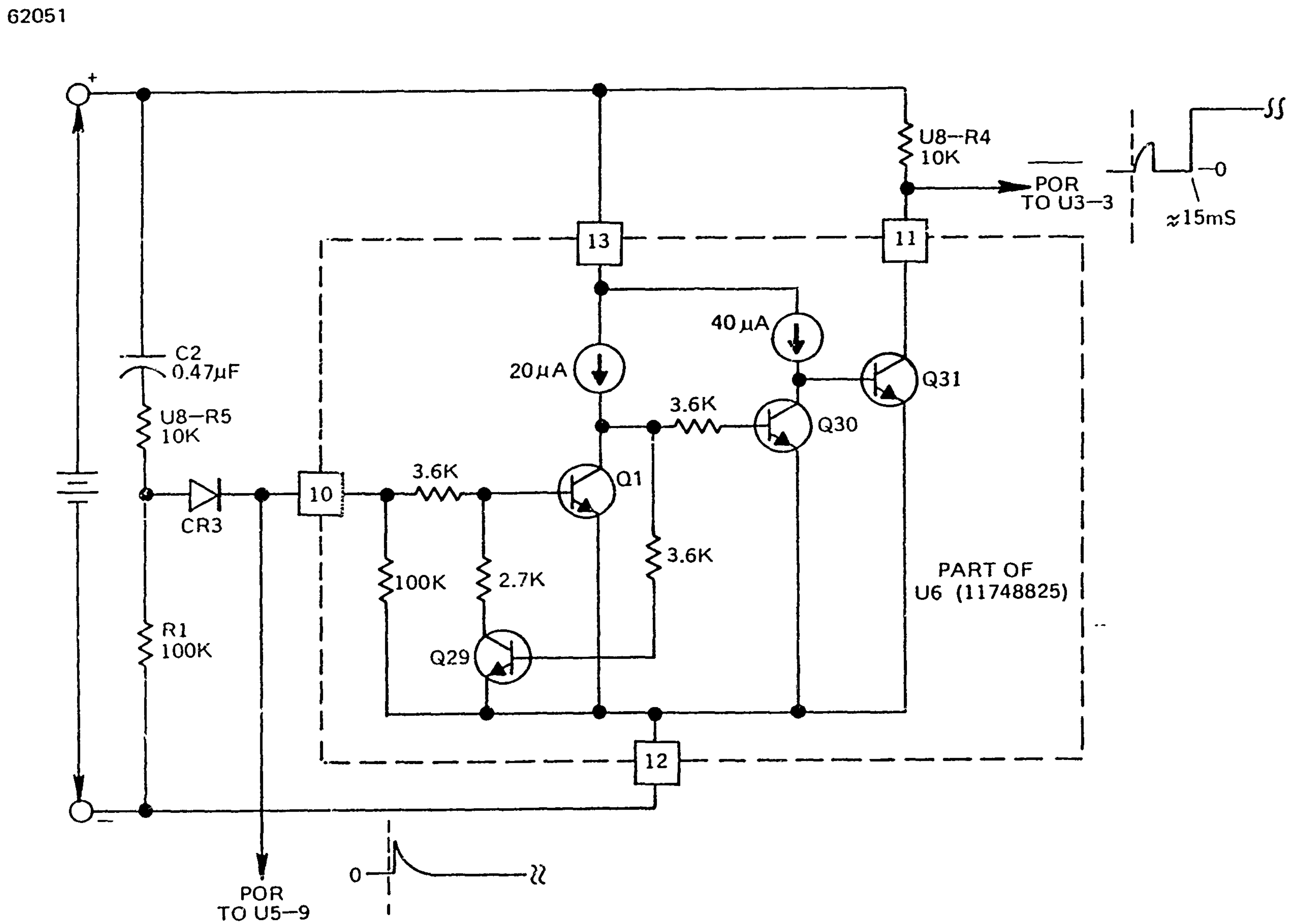

Figure 3-5. POR Circuitry

perhaps 200 Kohms. Even using the maximum value of discharge resistance and allowing five time constants to discharge C2, the circuit should be ready for re-application of battery voltage in less than one second. This is true only if removal of the battery would result in complete loss of power. There is a 68 μF filter capacitor connected to the power source (C1 of figure 3-1) and it is this capacitor which determines the rate at which the supply voltage falls when the battery is removed. Thus, a much longer time constant is involved than that of the POR circuit alone, and several seconds must transpire before the circuit will again generate a valid POR signal.

3.4 TRIGGERING

3.4.1 MICROPHONE

The noise generated by firing a blank is detected by means of a miniature dynamic microphone mounted within the transmitter housing. The microphone signal is amplified and used to signal the microprocessor that a round has been fired and that the MILES circuitry must simulate the round by generating the appropriate set of coded signals.

The microphone is mechanically loaded by a mass and cushioned to make it relatively insensitive to mechanical shocks to the weapon. Its aperture is protected by a cellular plastic material which is transparent to the acoustical transient produced by firing the blank.

3.4.2 MICROPHONE AMPLIFIER

The microphone signal is amplified and limited by circuitry which is part of a large scale integrated circuit (LSI) U6 (see figure 3-1). The applicable portion is reproduced in figure 3-6.

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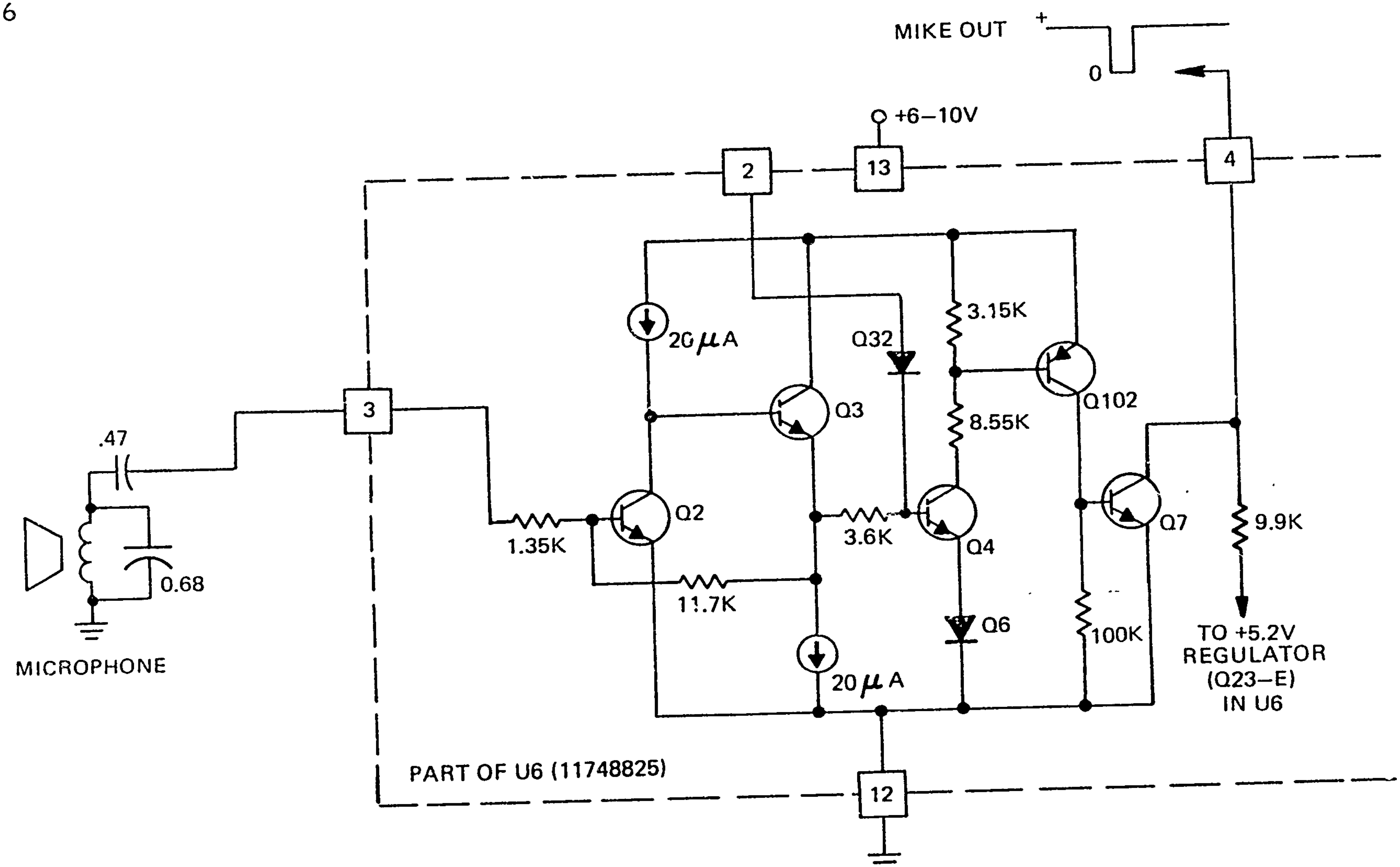


Figure 3-6. Microphone Amplifier

As will be seen from the latter figure, the microphone, loaded by the 0.68 μF capacitor, is compacitively coupled to the amplifier input. Q2 and emitter follower Q3 form an inverting feedback amplifier. A negative pulse from the microphone causes Q4 to begin to conduct if the signal level is large enough to overcome the combined drop of the emitter-base voltage of Q4 and the diode in series with its emitter. This threshold prevents adjacent weapons and mechanical shocks from generating an output pulse. When Q4 conducts, Q102 and Q7 are turned on, producing a brief negative pulse at pin 4 of U6. This pulse is then used as a trigger signal by the microprocessor.

The input at pin 2 of U6 is employed in Dragon, Viper, and TOW to invert the positive trigger signal developed in these units and thereby produce the negative trigger required by the remaining associated circuitry. The positive trigger signal is employed in Dragon, Viper, and TOW to interface properly with the requirements of the associated ATWESS device. For more details, refer to subsection

3.4.3 SENSITIVITY ADJUSTMENT

No sensitivity control is provided in the form of amplifier gain adjustment. It is possible to vary the size of the 0.68 μF capacitor presently shunting the microphone. Reducing this capacitor increases the microphone output for a given audio input. At present, all applications of the microphone are able to employ the same 0.68 μF capacitor size.

3.4.4 VEHICLE LCA WEAPON TRIGGER CIRCUITRY

The laser codes transmitted by the LCA vehicle weapon simulators are initiated by actual vehivle triggers. An electrical signal is picked off the vehicle trigger circuit and interfaced to the LCA

by cable. In the LCA, optically coupled isolators are used to interface the electrical trigger signals to the LCA electronics (refer to figure 3-7). The conditioned trigger signals are continuously monitored by the 1802 microprocessor on the external flag input lines as input parameters. An exception to this is the coax machine gun in the blank fire mode. A microphone is physically located in the close proximity of the coax blank fire adapter. The microphone pickup signal (interfaced by cable to the LCA) is amplified in the LCA and used in place of the coax machine gun weapon trigger (refer to subsection 3.2.3.

3.5 ENCODERS

3.5.1 SMALL ARMS

The small arms TES encoder is designed as a microprocessor based unit (refer to figure 3-1). The main components of the encoder are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software program is stored, Laser Driver Circuit (U5), and Laser Driver interface circuit (U6). The TES encoder is utilized with one of four different weapons determined by two weapon ID straps (jumper wires).

a. M16 rifle
b. M60 machine gun
c. M2/M85 machine gun

The basic clock rate for the 1802 microprocessor is 1.536MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536MHz crystal. The complete TES encoder operation is controlled by the microprocessor software program. Various

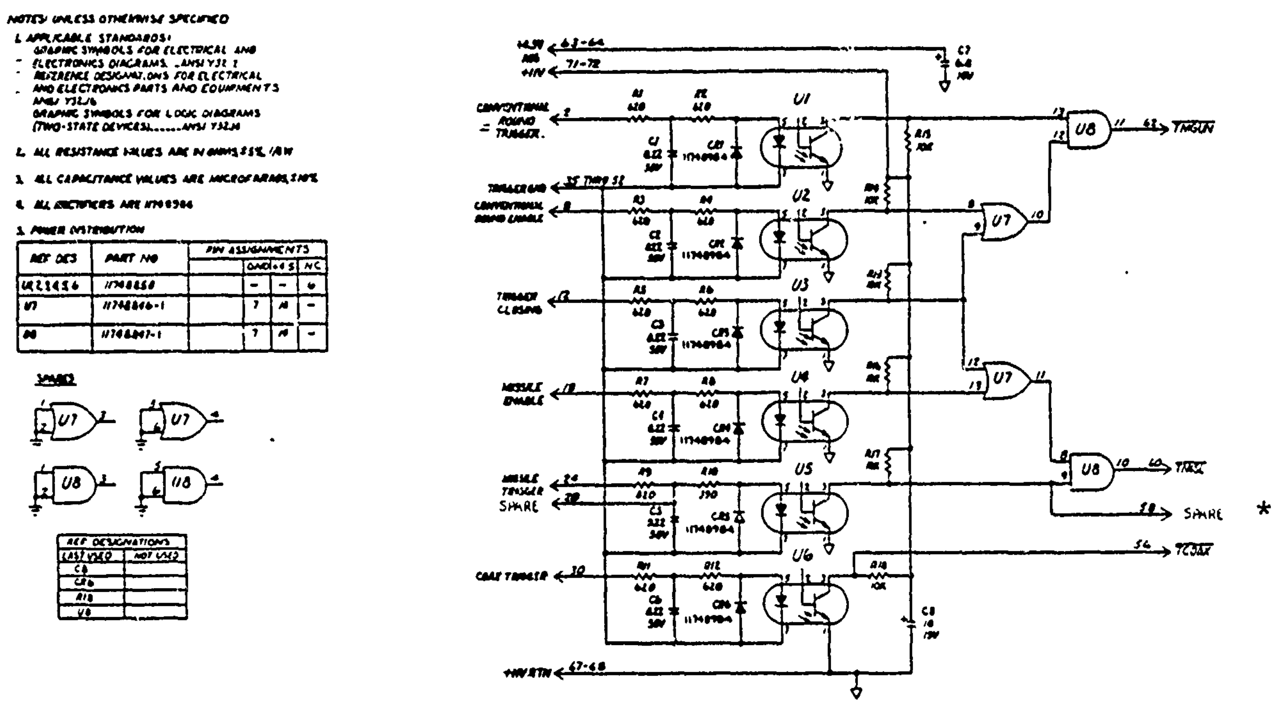


Figure 3-7. Trigger Interface Schematic Diagram

input parameters are monitored by the microprocessor and dependent upon these parameters; outputs are generated to perform the required output functions. The TES encoder has three modes of operation: dry (silent) fire, blank fire enable, and boresight mode. The 1802 microprocessor is programmed to enter the IDLE mode between all encoder operations to conserve battery power. Input parameters are monitored by the microprocessor on four external flag inputs or the interrupt input port. Trigger activation (signal TRIG*), control key engagement, and audio from the blank fire microphone are gated into the interrupt input port.

Eight input parameters, two weapon ID bits, control key, weapon key, dry fire signal, boresight mode signal, semiautomatic signal, and trigger activation are monitored on the four external flag inputs. The eight input parameters are multiplexed into the four flag inputs by a quad 2 to 1 multiplexer (U1) controlled by the 1802 microrpocessor Q output. For the different modes of operation, the microprocessor generates the load and fire pulses for the required weapon code words at the 3 KHz bit rate. These pulses are output to the Laser Driver circuit where the signals are conditioned to drive the laser electronics. The Laser Driver Interface circuit provides a regulated voltage for the microprocessor components from the 9-volt battery source supply, provides a power on reset signal at power turn-on, amplifies and interfaces the audio pickup from the microphone, and provides a signal to illuminate the firing indicator LED when fire pulses are generated to indicate firing.

3.5.2 VIPER/DRAGON/TOW

The Viper/Dragon/TOW encoder is designed as a microprocessor based unit (refer to figures 3-2, 3-3 and 3-4). The main components are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software

program is stored, rounds-remaining display network (U1 and U9), Laser Driver circuit (U5), and Laser Driver Interface circuit (U6).

The complete encoder operation for the three weapon encoders, Viper, a single shot weapon, Dragon, and TOW tracking missile weapons, are controlled by the microprocessor software program contained in the one ROM. Selection of the weapon is accomplished by ID bits, refer to Section 3.2.6. The basic clock rate for the 1802 microprocessor is 1.53 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. Input parameters are monitored by the microprocessor and, depending upon these parameters, outputs are generated to perform the required output functions. Input parameters are monitored by the microprocessor on four external flag inputs or the interrupt input port. The trigger activation signal is input to both the interrupt input port and one of the flag inputs. Input parameters, weapon ID bits control key, and weapon key (Dragon only) are monitored on the flag inputs.

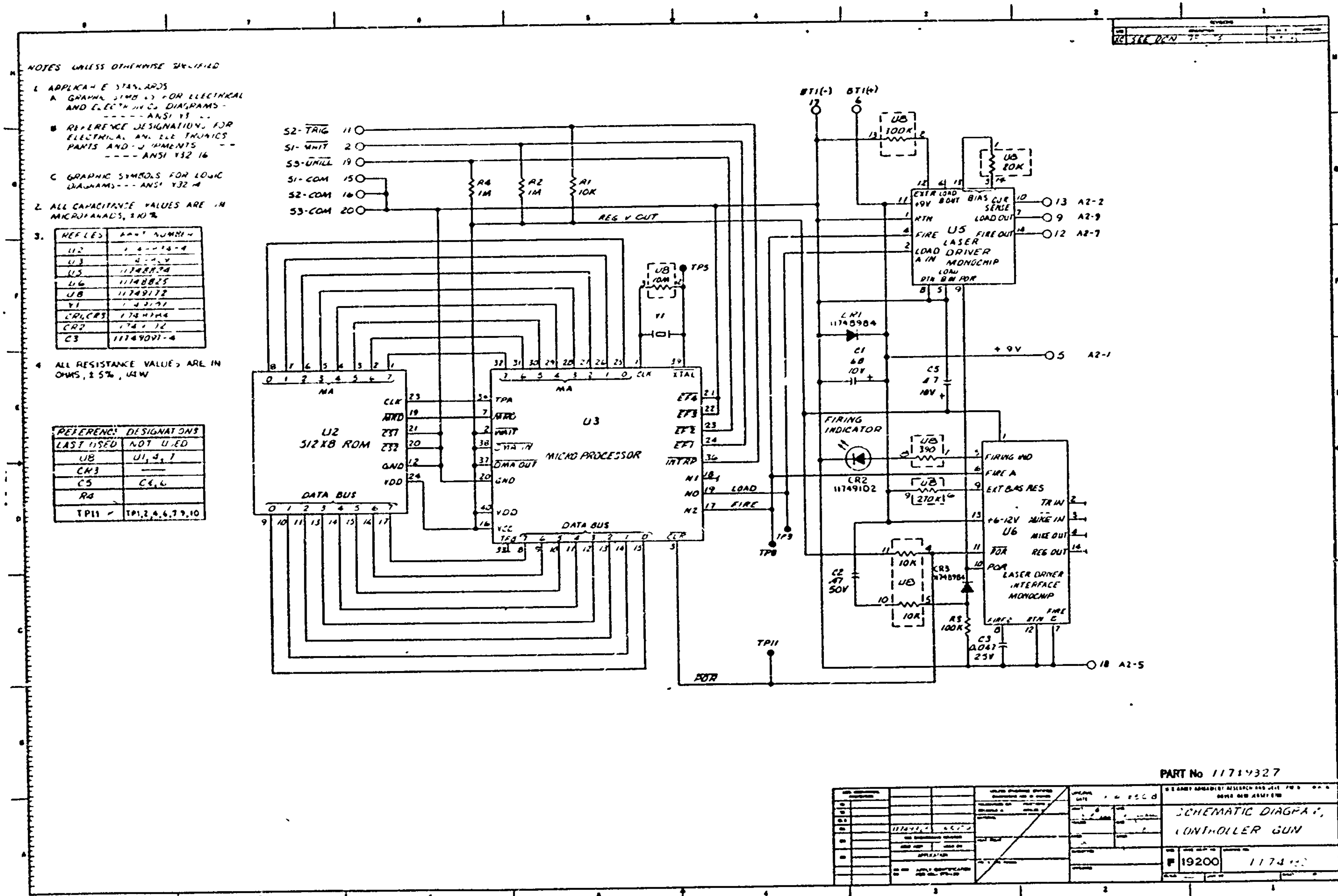
For the encoder operations, the 1802 microprocessor generates the load and fire pulses for the required weapon code words at the 3 kHz bit rate. For the rounds remaining display network function refer to Section 3.11.1. The load and fire pulses are output to the Laser Driver circuit where the signals are conditioned to drive the laser electronics. The Laser Driver Interface circuit provides a regulated voltage for the microprocessor components from the 9 volt battery power supply, provides a power-on reset signal at power turn-on, and provides a signal to illuminate the displays decimal point when fire pulses are generated to indicate firing.

3.5.3 CONTROLLER GUN

The Controller Gun encoder is designed as a microprocessor based unit (refer to figure 3-8). The main components of the encoder are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software program is stored, Laser Driver circuit (U5), and Laser Driver Interface circuit (U6). The complete encoder operation for the controller gun is controlled by the microprocessor software program. The basic clock rate for the 1802 microprocessor is 1.536 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. Three input parameters are monitored by the microprocessor, the trigger activation signal on the interrupt input port, and two switch input signals on two of the external flag inputs. The outputs of the two switches along with the tirgger activation causes the controller gun to transmit the near miss codes, near hit code, or the universal hit code. Upon trigger activation, the microprocessor generates the load and fire pulses for the required miss codes or either of the two hit codes at the 3 kHz bit rate. The load and fire pulses are output to the laser driver circuit where the signals are conditioned to drive the laser electronics. The laser driver interface circuit provides a regulated voltage for the microprocessor components from the 9-volt battery power supply, provides a power-on reset signal at power turn-on, and provides a signal to illuminate the first indicator LED when fire pulses are generated to indicate firing.

3.5.4 ENCODING FOR DEPENDENT TRANSMITTERS

On vehicles, laser transmitters and their associated analog electronics are physically located in the breach or in the close proximity of the weapon. Signals that control the laser electronics are generated in



... Controller Gun Schematic Diagram

the LCA transmitter encoder electronics and are interfaced by cable. The LCA is designed with the 1802 microprocessor as the central element. The basic clock rate for the 1802 microprocessor is 1.536 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. The 1.536 MHz clock is also divided down into other required clock rates in a counter divide network and distributed to logic circuits that support the microprocessor within the LCA. The complete LCA operation is controlled by the microprocessor software program. The LCA transmitter encoder receives transmission parameters from the data bus lines and gated timing and control signals to clock the parameters into working registers from the microprocessor (refer to figure 3-9). The first transmission parameter is the number of copies per code word to be transmitted which is clocked into countdown counters (U12 and U13). The second transmission parameter is the transmission encode data which is clocked into a 4-bit storage register (U10). The encoder data provides the correct laser load and fire pulses for the selected weapons. The last transmission parameter is the actual code bit pattern to be transmitted which is clocked into a circular parallel-to-serial shift register (U2). The clock signal for the code bit pattern also acts as a start signal for the LCA transmitter encoder.

3.6 MODULATORS

In this discussion we shall refer to "modulators" as those circuits which accept a "load" pulse from encoding logic and, as a result, ladle a precise amount of energy into an energy storage capacitor (figure 3-10). The circuit which discharges the capacitor into the laser diode upon receipt of a "fire" pulse is also included.

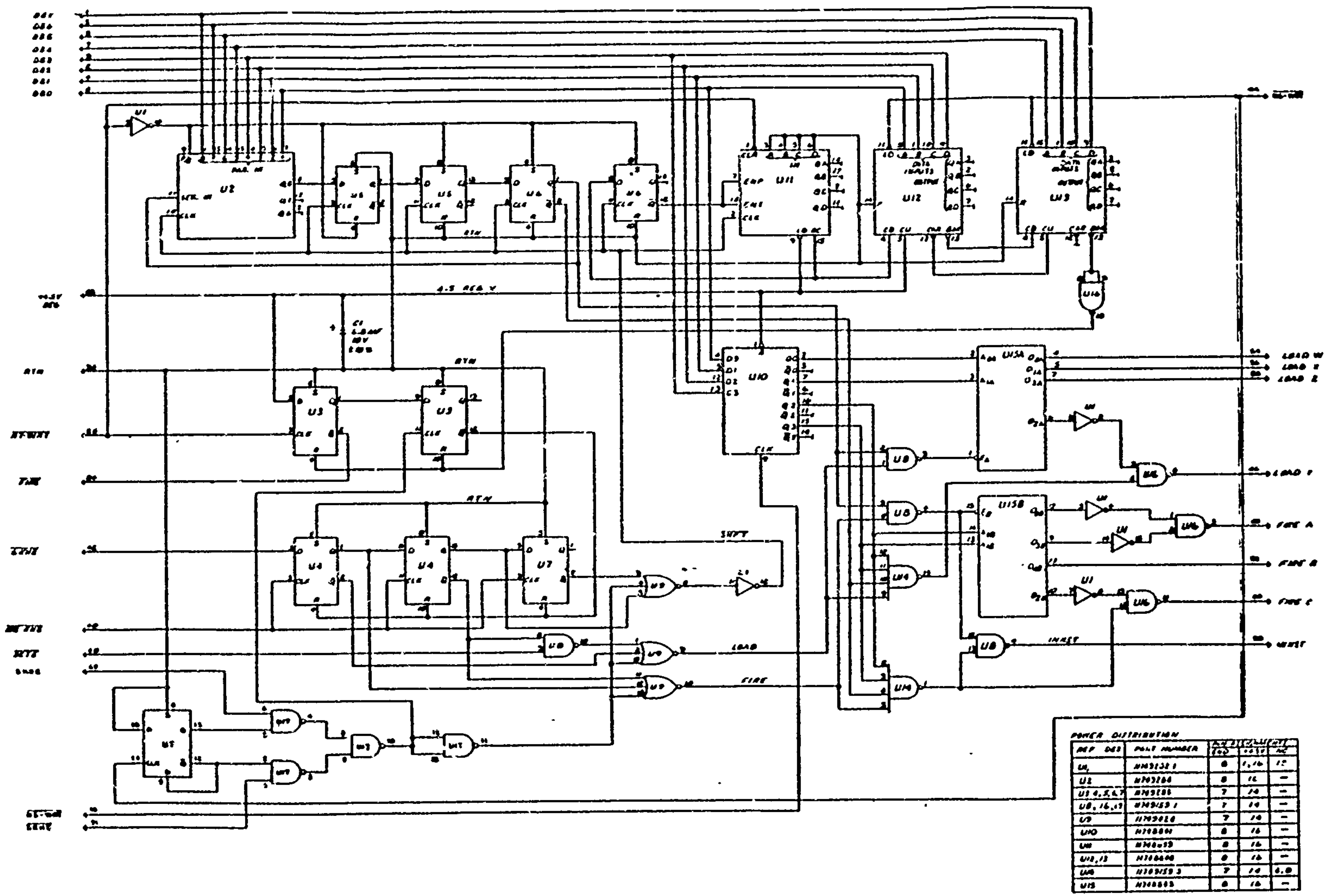


Figure 3-9. Transmitter Interface Logic Diagram

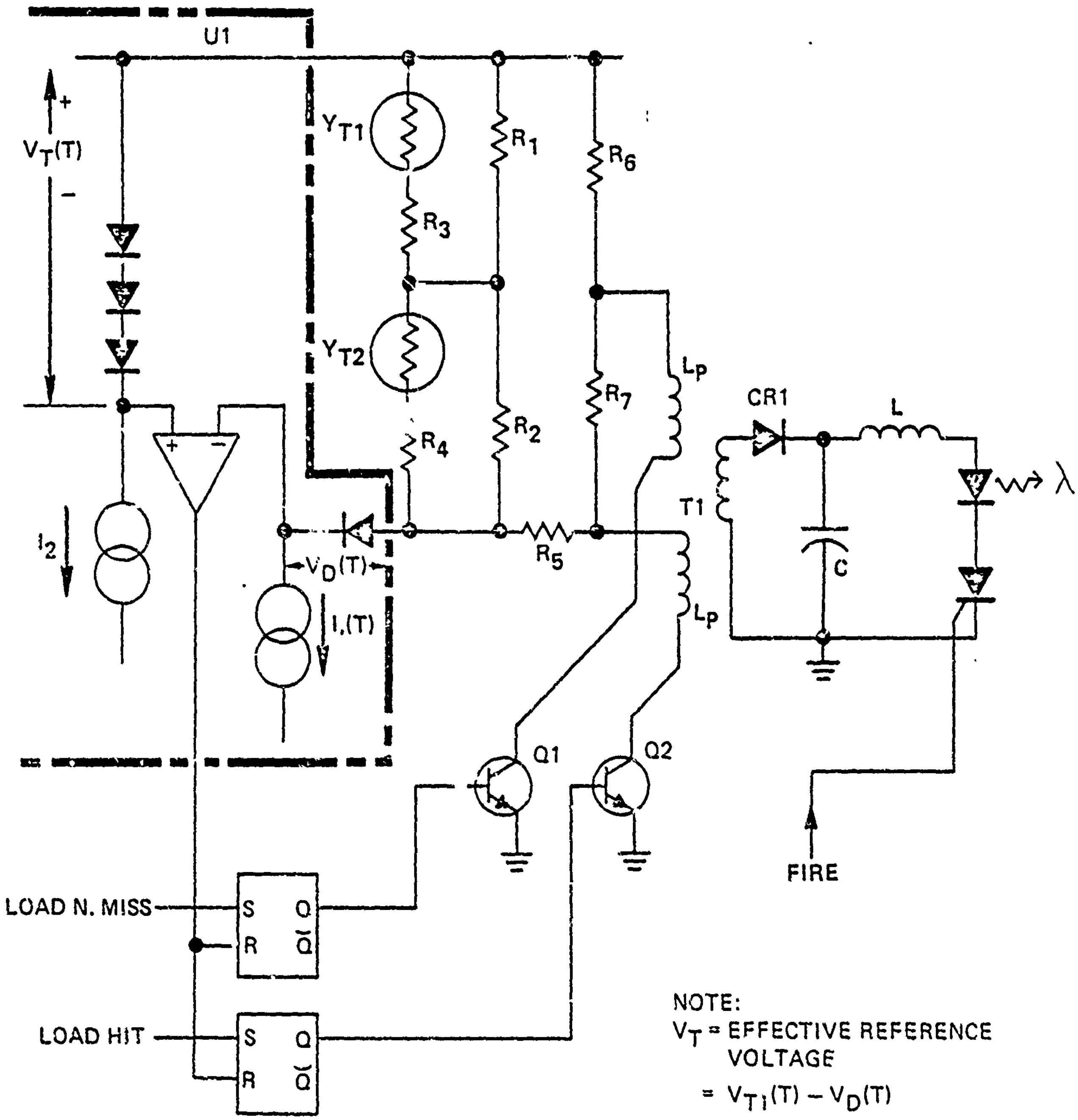


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Figure 3-10. MILES Transmitter, Simplified Schematic

3.6.1 ENERGY LADLING

Figure 3-10 shows the modulator circuit. The circuit works by building a magnetic field in the primary of transformer T1 when Q1 or Q2 turns on. When that magnetic field contains a precise amount of energy, $I^2Lp/2$ (as measured in its current), transistor Q1 or Q2 turns off and the energy is transferred to voltage appearing on the energy storage capacitor C. Diode CR1 prevents discharge of the capacitor back through the transformer secondary. The capacitor now contains a precise energy controlled by the current at which Q1 or Q2 was turned off. We say that the energy from the primary has been "ladled" to the capacitor.

The precision element in the energy ladle is the pair of current sensing resistors R6 and R7. When the voltage across these resistors reaches a set threshold, as determined in the Laser Driver integrated circuit, U1, the transistor Q1 or Q2 is turned off. The circuit is configured such that the trigger point for energy transfer is independent of power supply voltage. There is a temperature dependence in the trigger point inside U1, but this is compensated in the TC network discussed in 3.6.2.

3.6.2 TEMPERATURE COMPENSATION

e amount of current through the laser diode must vary with temperaure in order to compensate for the laser diode's inherent variations. Those variations tend to lower laser output energy as the temperature increases.

The mechanism for causing a programmed current variation is the pair of thermistors YT1 and YT2. Table 3-8 below shows thermistor variation

with temperature at high, low, and room temperatures. Component specifications may be consulted for more detailed data.

TABLE 3-8

THERMISTOR RESISTANCE VS. TEMPERATURE

Temperature	YT1 (ohms)	YT2 (ohms)
-35°C	14.17K	649.3K
+25°C	1K	30K
+85°C	152.4	3.272K

The thermistor network forms one leg of a voltage divider between the current sense resistors and the comparator in U1. As the temperature increases, the amount of divider attenuation increases, causing the transformer primary current to reach a higher value before the energy transfer takes place. This obviously increases the charge on storage capacitor C of figure 3-10, and increases the drive to the laser diode. The opposite effect is observed at low temperatures.

3.6.2.1 Analysis of Temperature Compensation (TC) Circuit

Figures 3-10 and 3-11 show a simplified schematic of the MILES laser transmitter and an equivalent circuit. Figure 3-11 also shows equations governing the circuit. The artificial resistor R_2 in figure 3-11 represents the total resistance of Y_{T1}, R3, R1, Y_{T2}, R4 and R2 in figure 3-10. The quantities R, L, and E in the laser discharge loop represent parasitic resistance, inductance, and forward voltage drops in the laser diode and SCR. As the note states, the resistance in that loop is negligible and the output circuit is not damped appreciably. The quantity E is approximately 2 volts.

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ED MILES

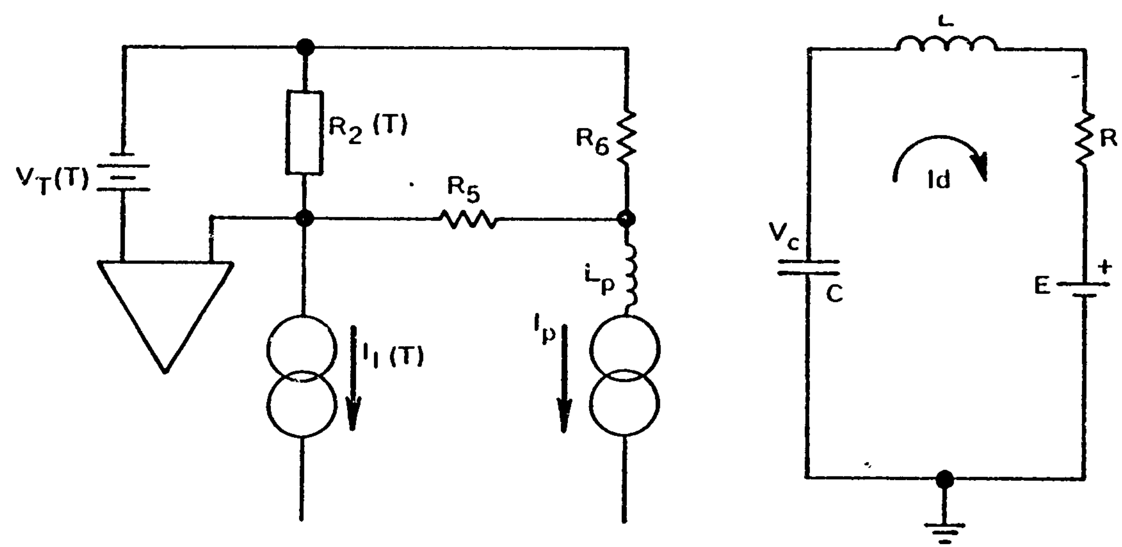
PARAMETER		VALUES
L	=	75×10^{-9} H
R	=	2 OHMS
R_6	=	2 TO 10 OHMS
R_5	=	11K
R_2	=	3K TO 28K

V_T (25°C) = 1.1V

I_I (25°C) = 100 μA

E = 2 V

$L_P = 1.25 \times 10^{-3}$ H



$$(1)\quad I_p = (1/R_6)\left[V_T\,(1 + R_5/R_2) - I\ R_5\right] \text{ AT TURN-OFF}$$

$$(2)\quad V_c = I_P \sqrt{L_p/C}$$

$$(3)\quad I_d = \frac{(V_c - E)\,(1 - R^2C/4L)\,\exp\left[-RA/2L\omega\right]}{\omega L}$$

WHERE

$$\omega = \sqrt{1/LC - R^2/4L^2}$$

$$A = \tan^{-1} \sqrt{(4L/R^2C) - 1}$$

NOTE: IN PRACTICE, R IS NEGLIGIBLY SMALL AND EQUATION 3 REDUCES TO:

$$(3a)\quad Id \approx (V_c - E) \sqrt{C/L}$$

Figure 3-11. Equivalent Circuit - MILES Transmitter

Bias current I (T) and threshold voltage V_t (T) are derived in the laser driver IC. As the notation suggests, these vary with temperature and the thermistor network must also compensate for these variations. Any thermal testing of the modulator must, therefore, include subjecting the laser driver IC to the thermal environment.

3.6.2.2 Development of a Production Technique

A convenient point to measure TC network performance is the voltage, Vc, across the capacitor. Vagaries of the laser diodes and the high frequency discharge network are eliminated and the network may be tested and calibrated over temperature. Implementation of temperature compensation is governed by data obtained on circuit elements as follows:

a. The TC network must be characterized such that we know how to adjust network resistors to achieve any desired V_c profile against temperature.

b. Diode statistics must be measured so that we are able to make decisions on whether to customize each diode's TC network or use a common one. Results show that multi-heterostructure diodes may use a single TC network for each weapon type. Single heterostructure diodes require a customized netowrk derived from screening data on each diode.

Characterization of TC Network

Measurements of the TC network have been made in a convection oven in order to characterize the circuit. Figure 3-12 shows a schematic of

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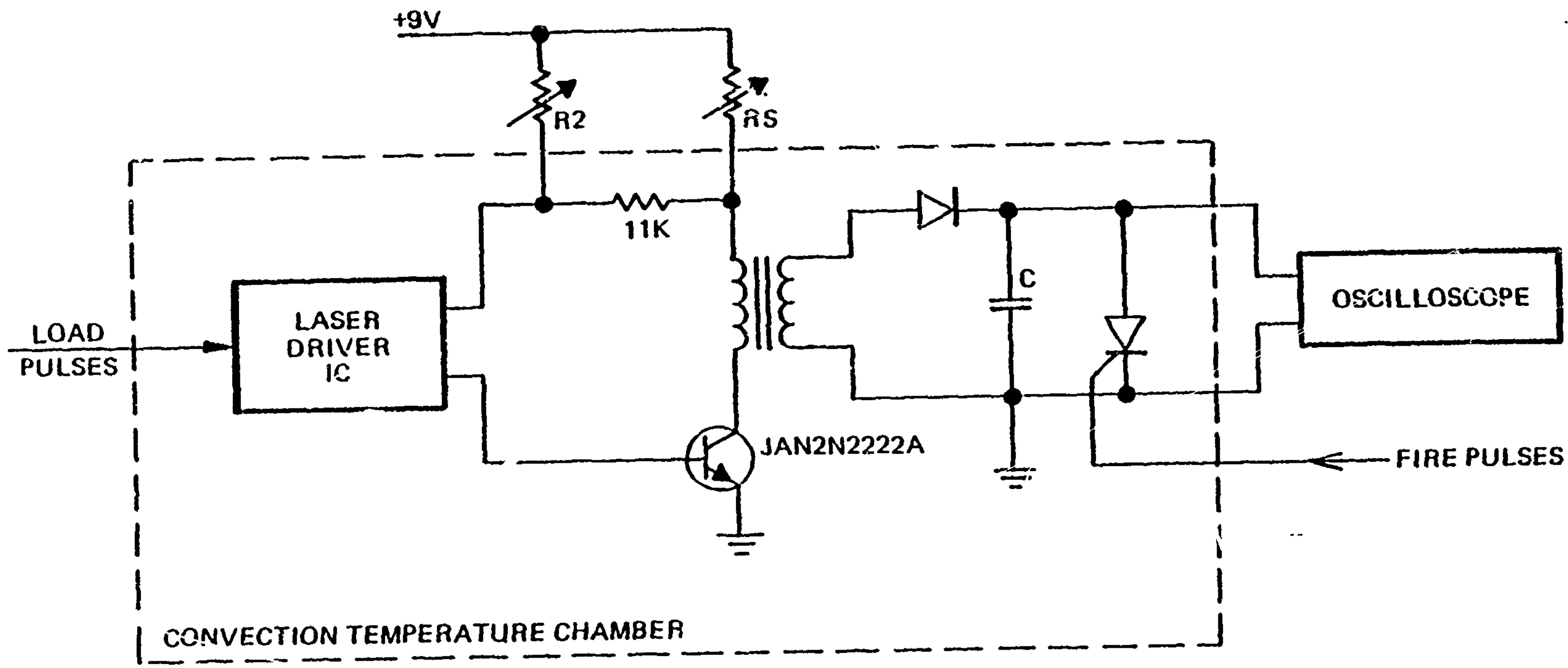

Figure 3-12. Schematic, Temperature Compensation Characterization

the set-up. Decade resistances R_2 and R_s represent the TC network and the sense resistor respectively. Voltage across the storage capacitor is measured as temperature, R_2, R_s, and capacitor values are changed. Figures 3-13 through 3-19 show the results of tests on an ED MILES circuit.

Diode Screening in the Dry Box

During the MILES ED program, it was necessary to screen a large number of laser diodes to obtain statistical data on temperature characteristics. A test fixture, called the "dry box" was devised which allowed quick repeatable measurement of diode output power, capacitor voltage, and diode current while diode temperature was varied. Figure 3-20 shows the scheme.

The diodes are mounted on a copper plate to which two copper tubes are brazed. For cooling, liquid nitrogen is run from a dewar through a coil to vaporize it and through one of the tubes on the copper plate. For heating, dry air is run through a heating coil wrapped around an electric heater and then through the other tube on the copper plate.

The entire fixture is enclosed in a plastic box which is purged and maintained at a positive pressure with dry nitrogen. This is to eliminate any water condensation on the diode or the radiometric optics. An EG &G model 460 radiometer is used to measure output energy per pulse into an f/2.5 cone. A fixture maintains aperture and distance from the diode to insure f/2.5.

Using this technique, it is possible to reliably and repeatably run through a +25°C, -35°C, +85°C, +25°C temperature cycle in about 30 minutes.

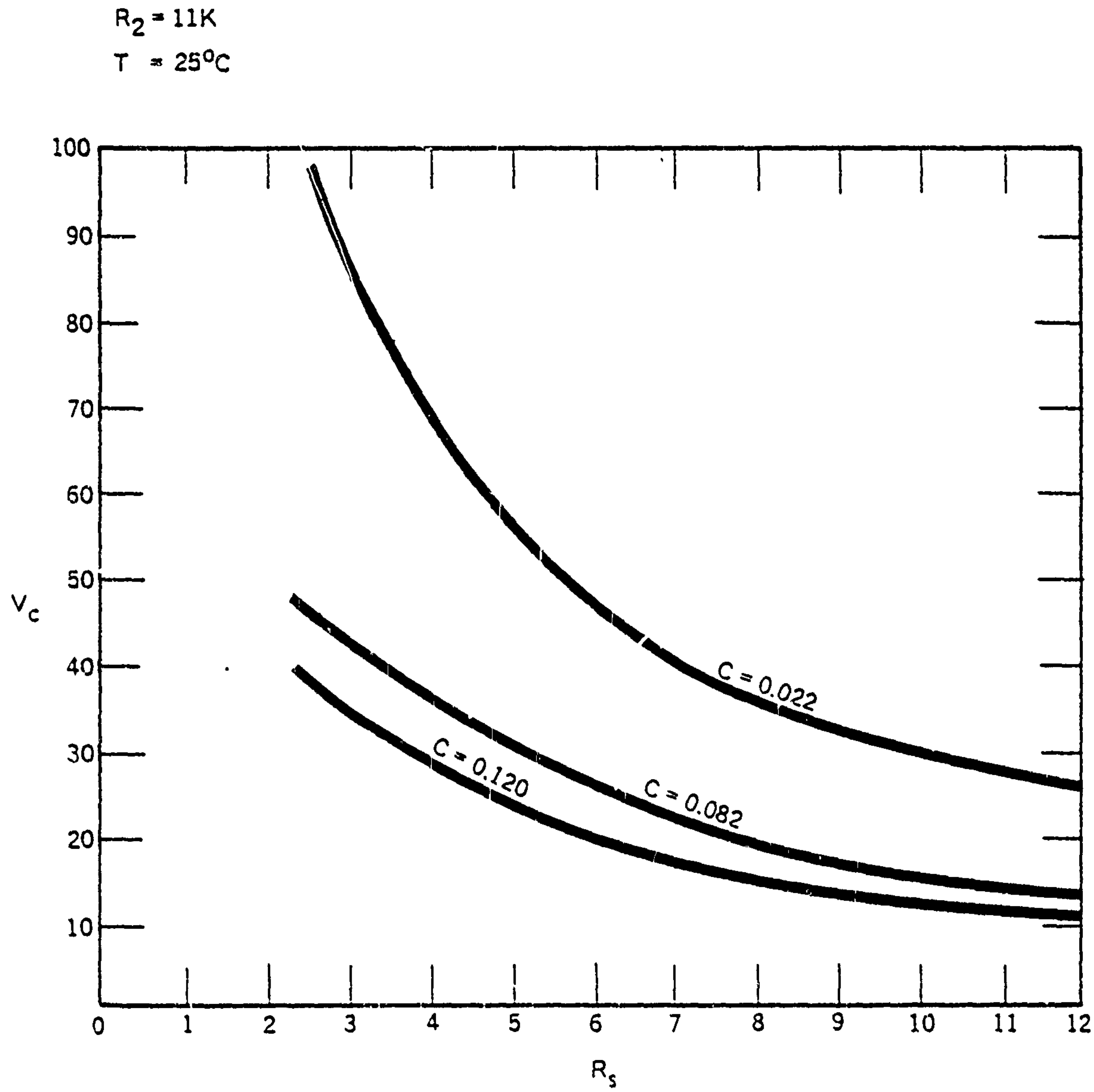

Figure 3-13. MILES Transmitter - Capacitor Voltage versus R_S

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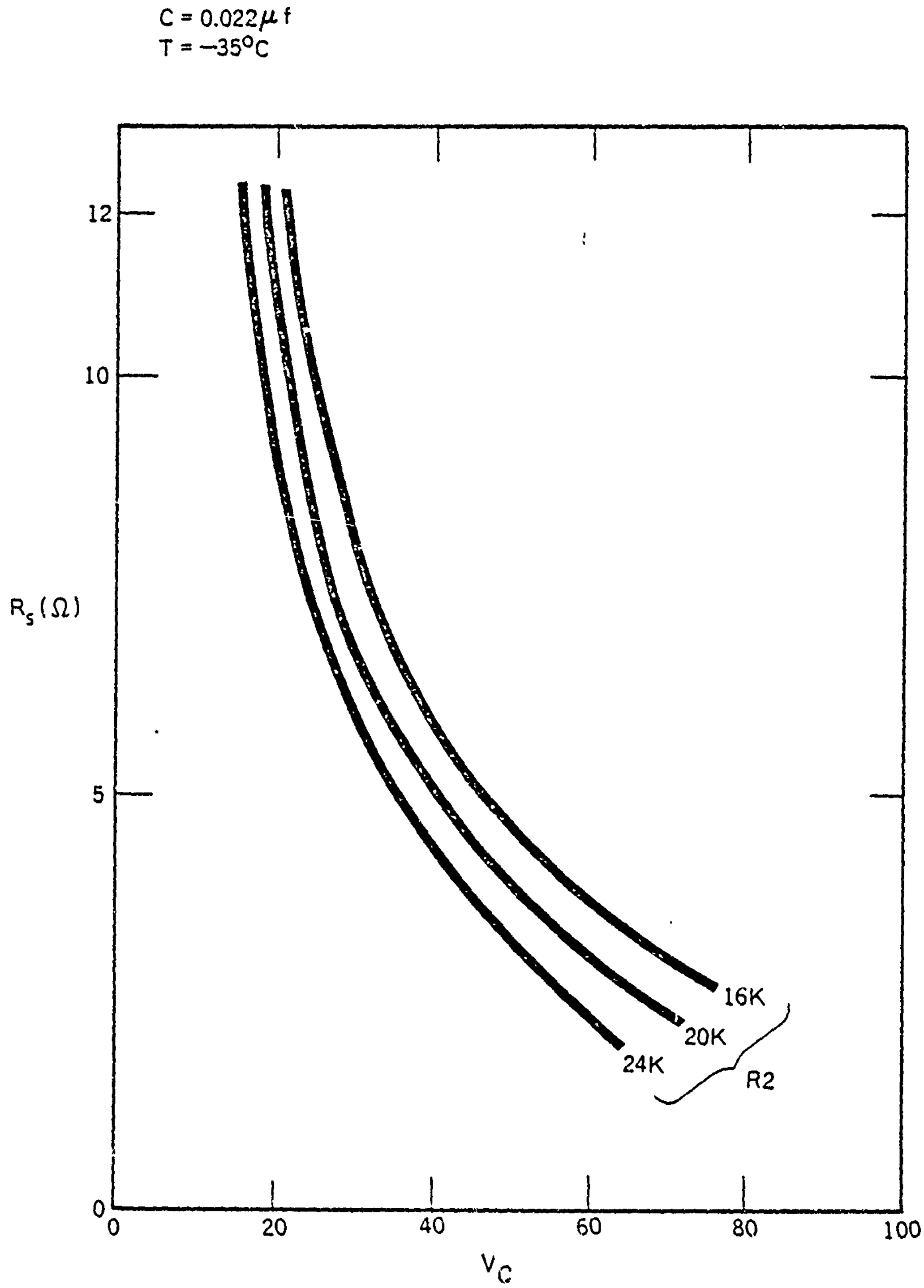

Figure 3-14. MILES Transmitter - R_S versus Capacitor Voltage

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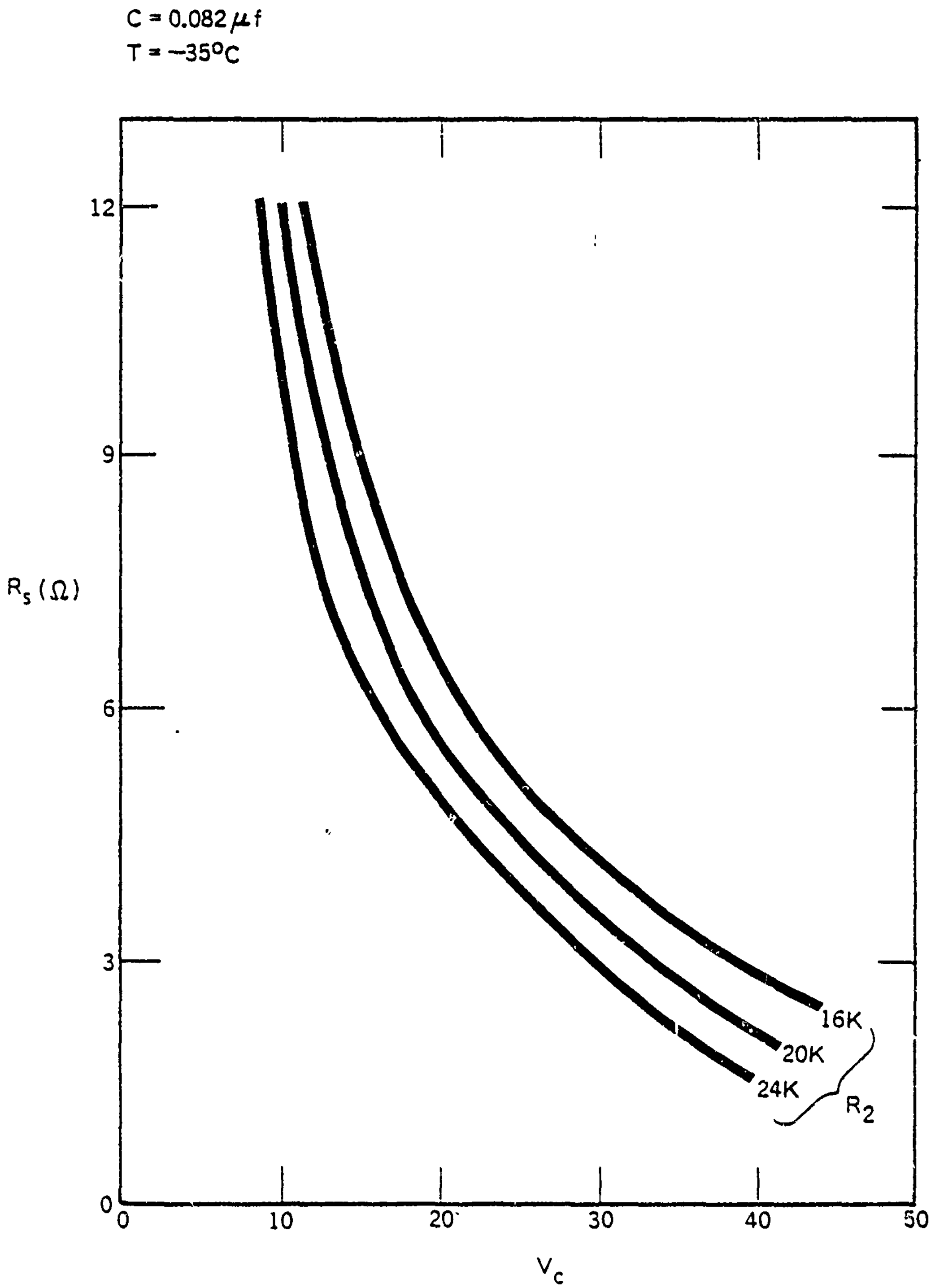

Figure 3-15. MILES Transmitter - R_S versus Capacitor Voltage

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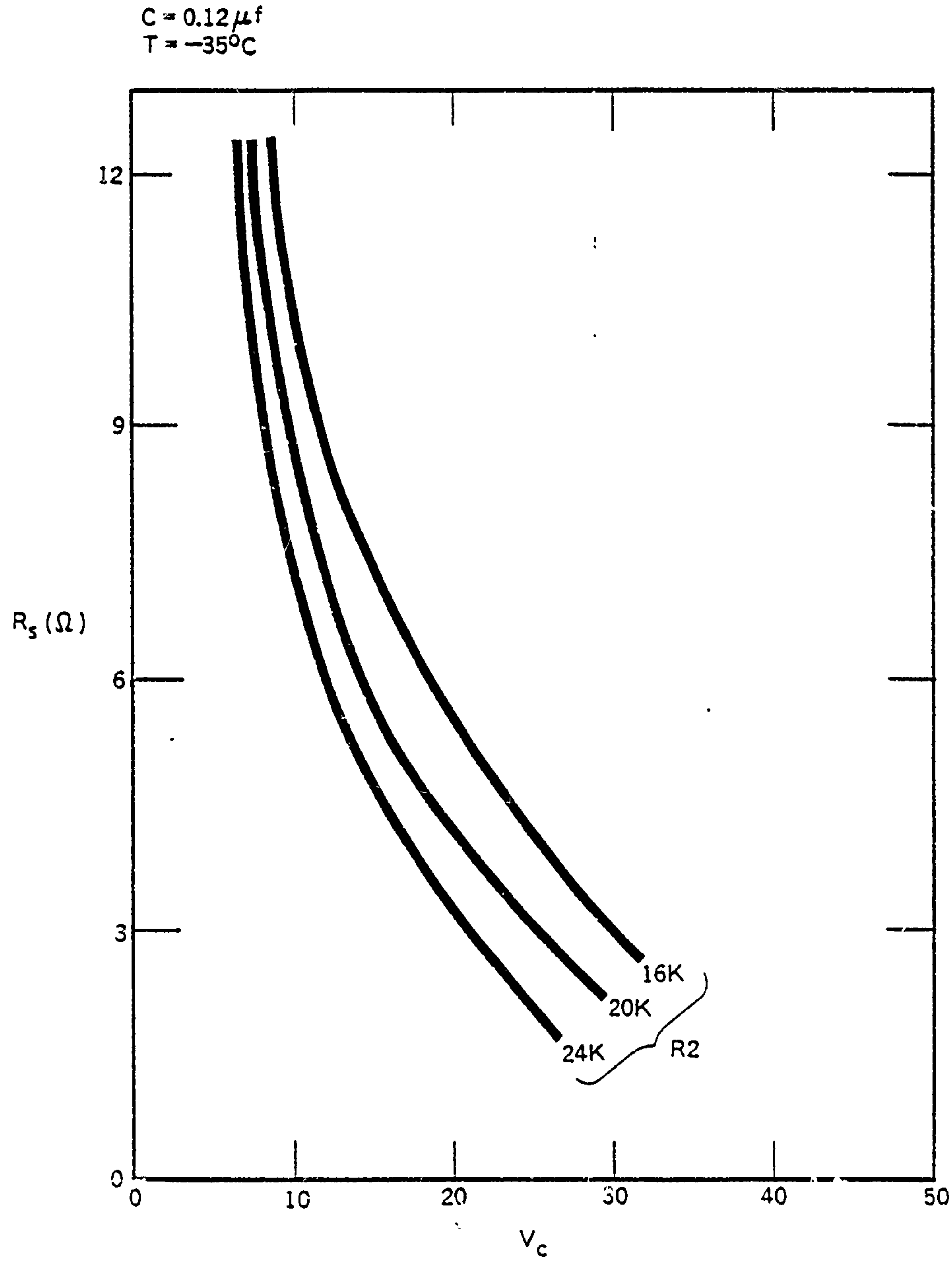

Figure 3-16. MILES Transmitter - R_S versus Capacitor Voltage

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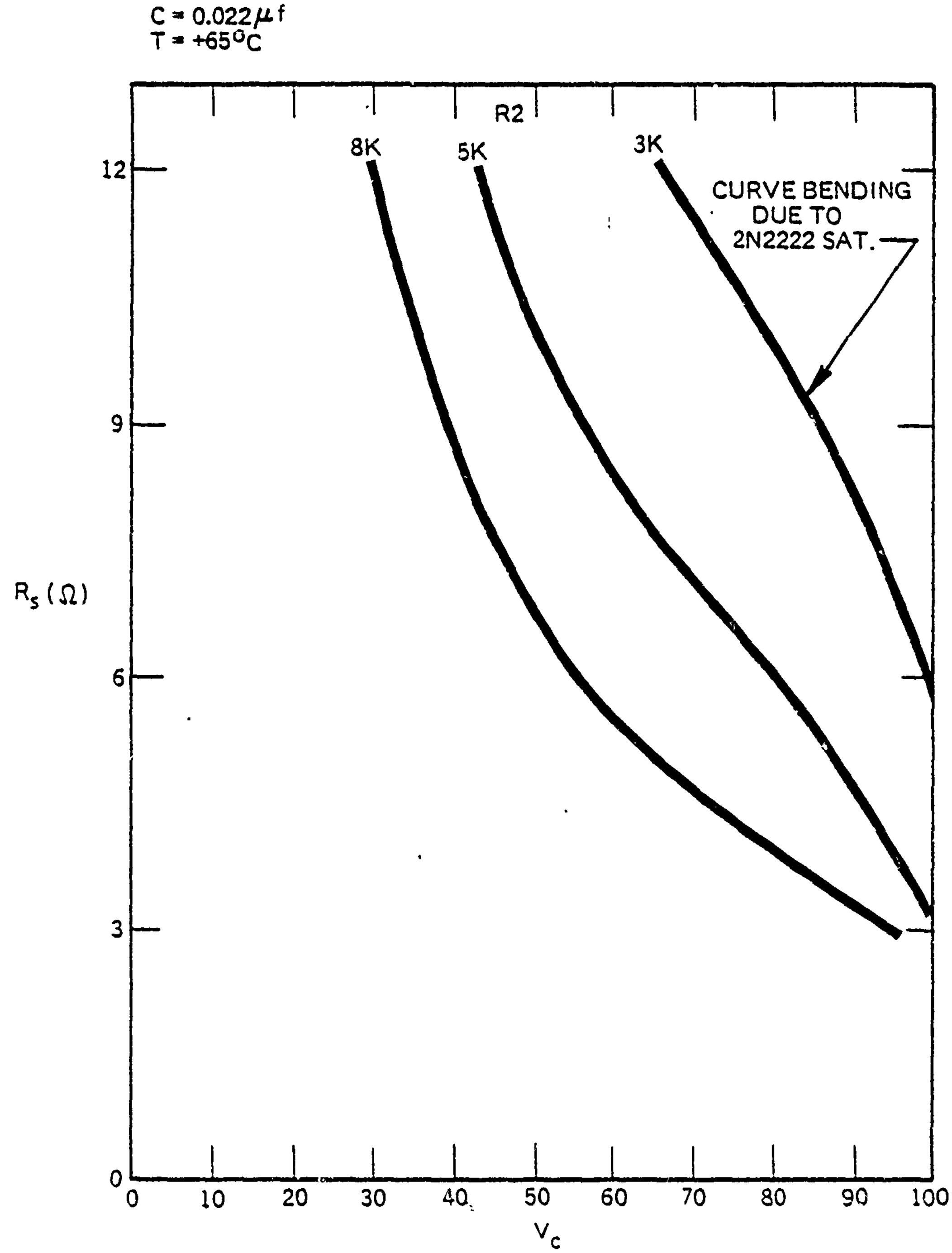

Figure 3-17. MILES Transmitter - R_S versus Capacitor Voltage

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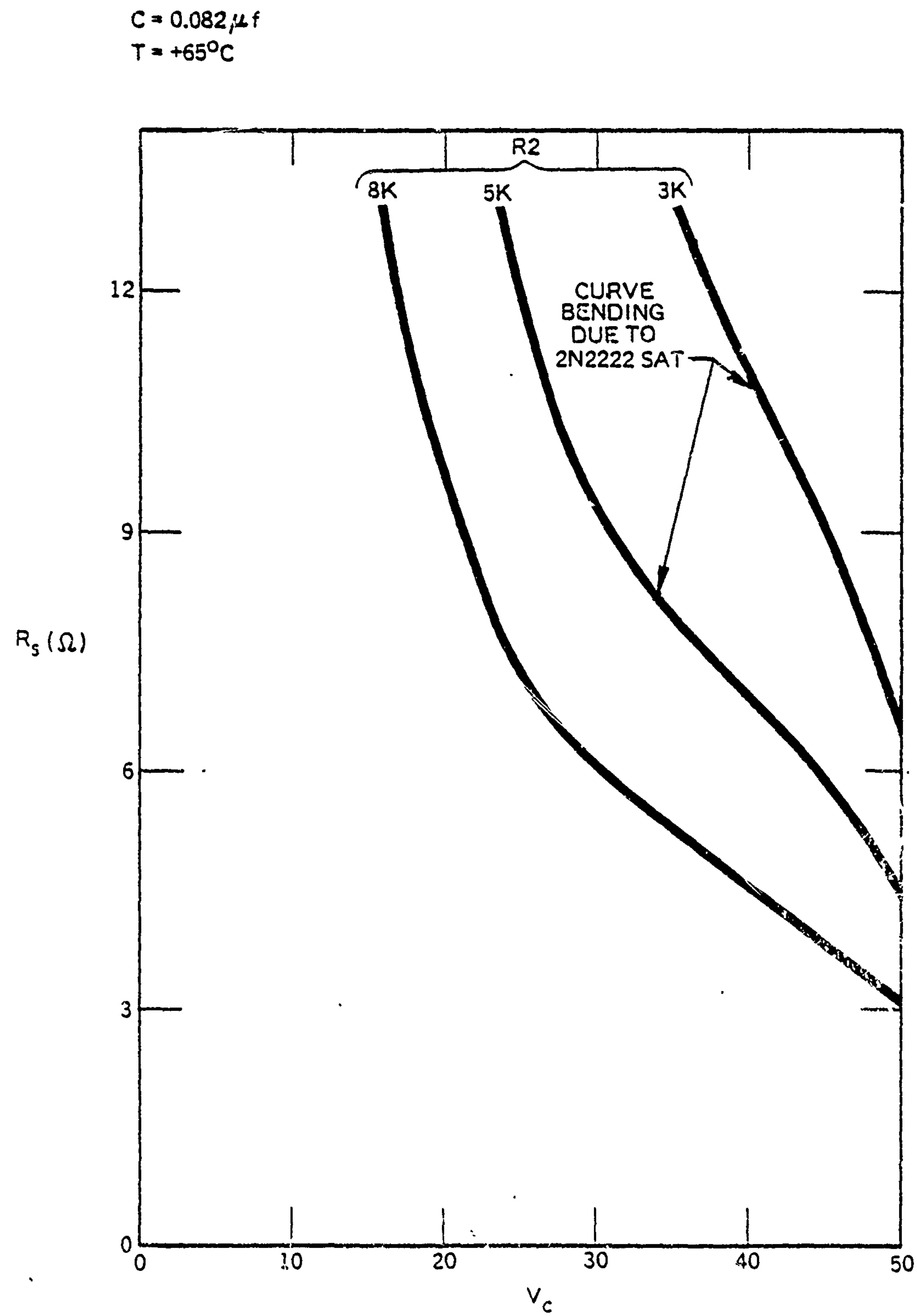

Figure 3-18. MILES Transmitter - R_S versus Capacitor Voltage

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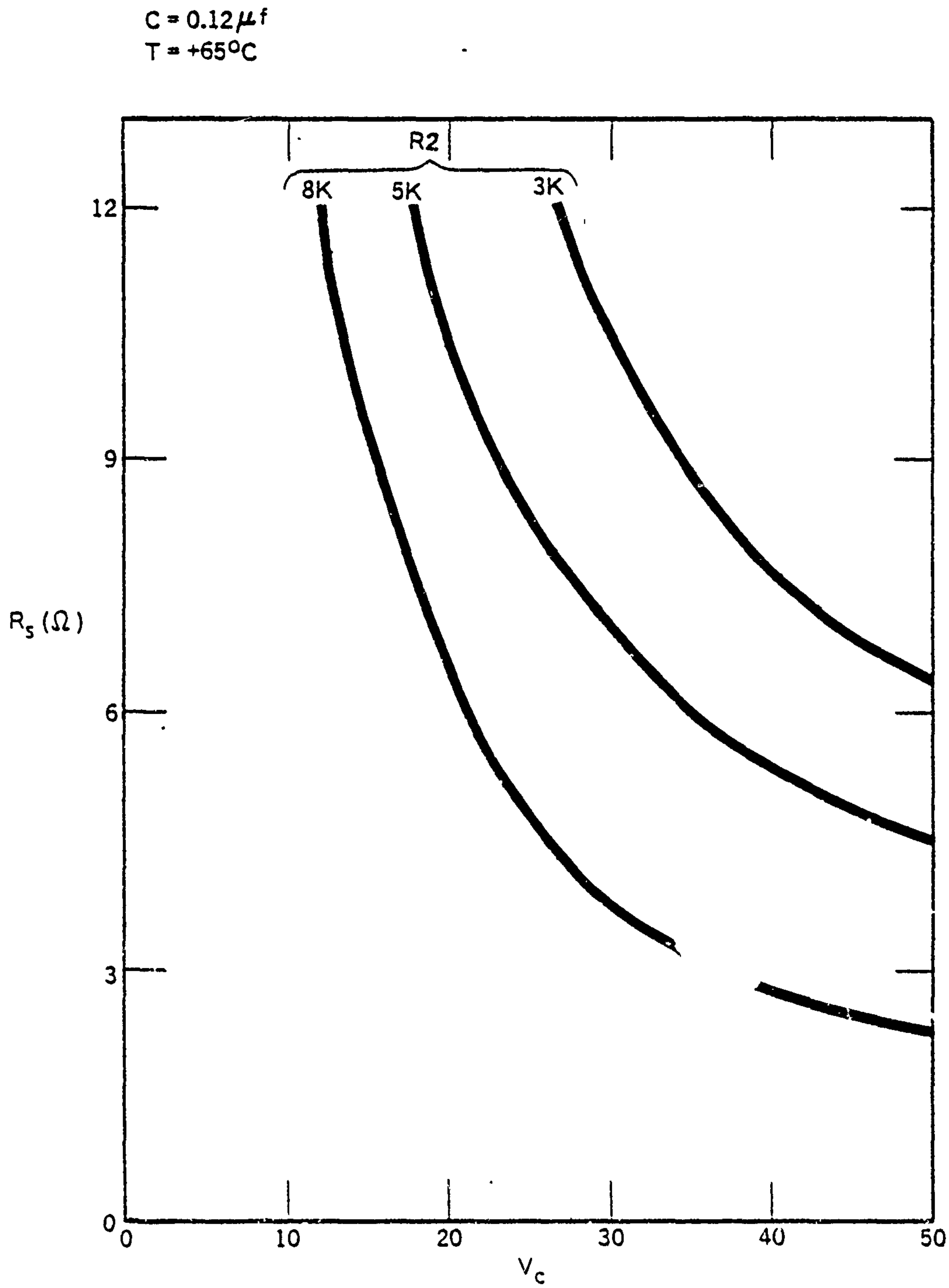

Figure 3-19. MILES Transmitter - R_S versus Capacitor Voltage

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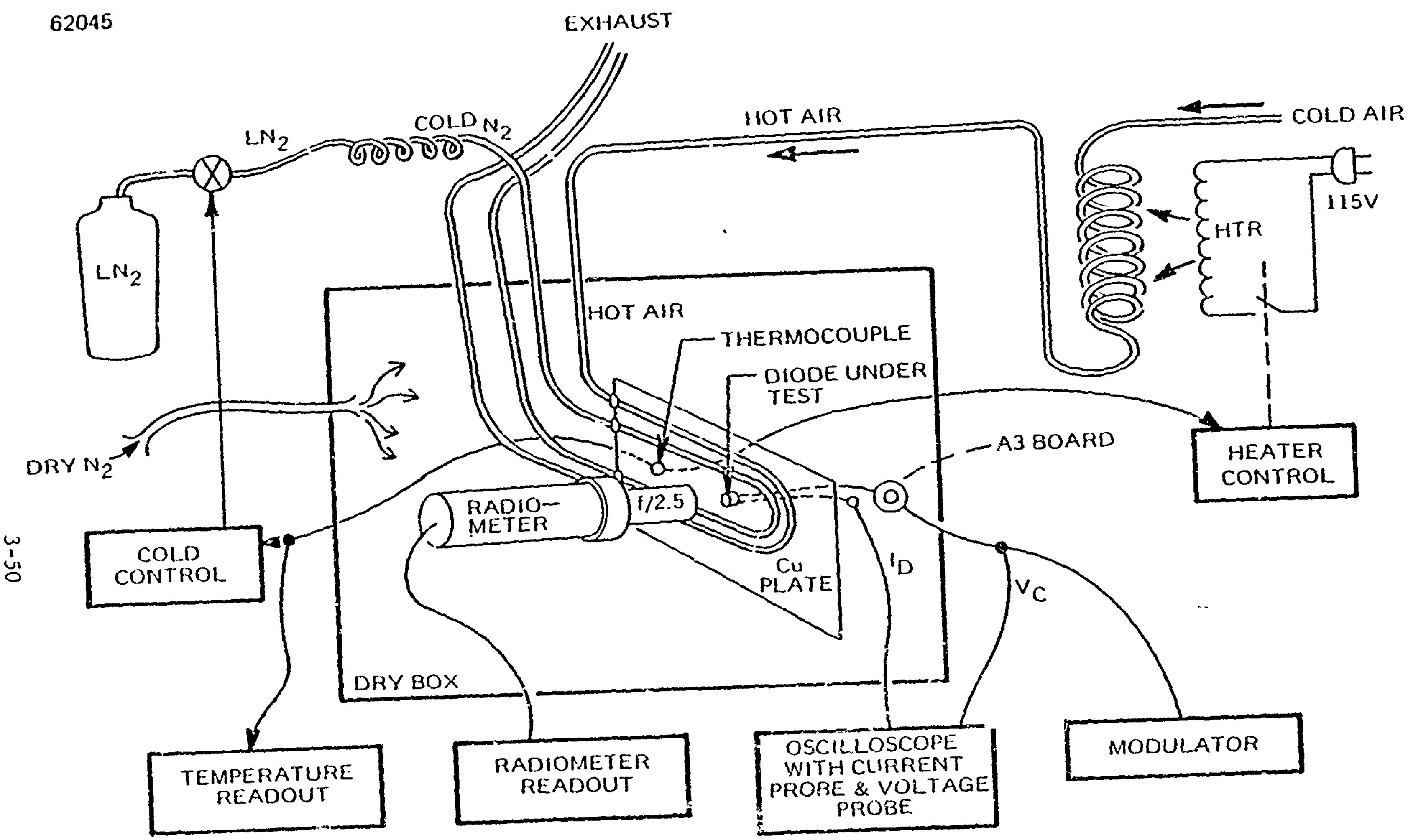

Figure 3-20. Test Setup, MILES Laser Diode Temperature Characteristics

Data was taken every 20°C. Temperature read-out and control is by a thermocouple attached to the plate near the diode.

3.6.3 POWER ADJUSTMENT

Laser output energy may be adjusted by varying current sense resistors R6 and R7 in figure 3-10. Kill energy is set by the sum of R6 and R7; near miss by R6 alone.

In production, these resistors are selected in test to adjust final laser output energy.

3.6.4 CALIBRATION IN PRODUCTION

Temperature compensation in ED was different for single heterostructure and multi-heterostructure devices. Multihet devices were found to be more stable in unit-to-unit temperature characteristics and were used exclusively in all three-mil applications (M16A1, M2, M85, M60, 105 coax, Viper and Controller Gun). Both types were used in all six-mil applications (Dragon, 105 mm main gun, 152 mm coax, 152 mm main, TOW, and Shillelagh). Three and six-mil refers to the length of the radiating laser junction.

Figure 3-21 shows the flow plan for calibrating transmitters. Incoming lasers are screened in the dry box for TC characteristics. Data from screening is used to decide on TC network values. For the diodes received in ED, all multihet diodes used in any single weapon type were given identical TC network values. All single-het diodes required customized TC networks which were installed at final test. Power resistors were installed in all units at final test.

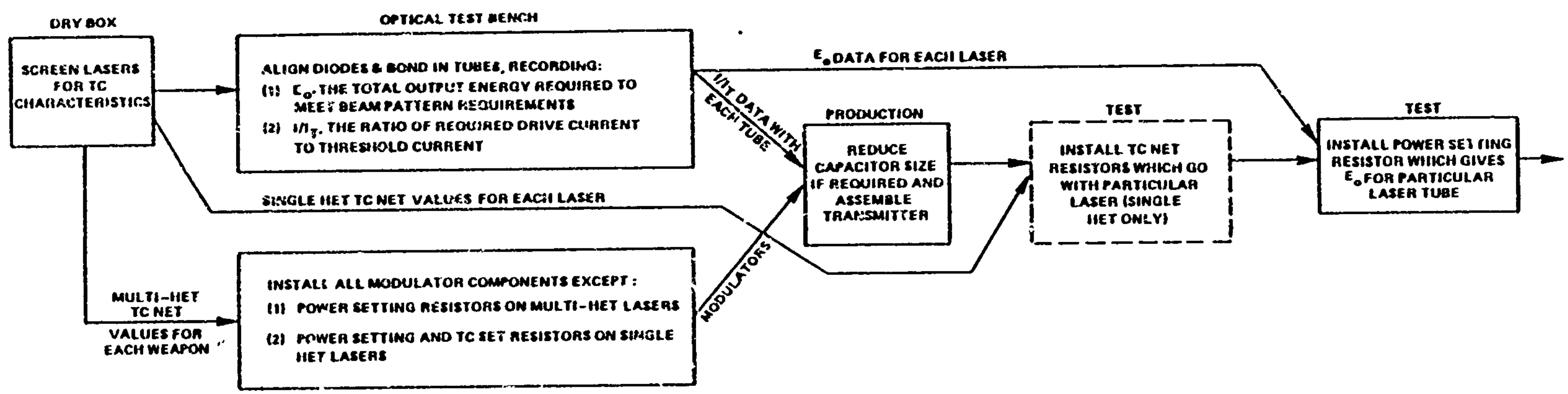

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Figure 3-21. Flow Plan - MILES Transmitter Calibration

The diodes were aligned and bonded in transmitter optics tubes using an optical test bench. The alignment and power setting criterion was that the laser far field beam pattern fall between maximum and minimum energy profiles for each weapon. Each laser tube driver was adjusted to accomplish the desired beam pattern. The ratio of diode drive current to diode threshold current was measured and if less than 1.4, the capacitance was later lowered at tube assembly. (This to avoid diode operation near threshold where output energy is overly sensitive to drive current). The total energy (E_o) exiting the transmitter output aperture was measured and recorded while the transmitter was operating within the allowable beam pattern profile tolerance.

At production test stations, after transmitter assembly, TC network select-in-test resistors were added to modulators if not already installed. The transmitters were then operated with adjustable resistors in place of sensing resistors R6 and R7. These were adjusted while total output energy was monitored until the output energy just matched E_o, the transmitter output energy which had been required to match beam energy profiles at the optical test bench. Resistance values matching the adjustable resistors were then installed and the output energy rechecked to complete the calibration.

3.7 LASER DIODES

3.7.1 DEVELOPMENT DURING MILES ED

A contract was let early in the ED phase to develop multiheterostructure diodes which could reliably handle MILES energy levels. This program resulted in an antireflection coating being added to previous designs which reduced internal optical heating considerably.

The prototype lots were tested and found adequate for the MILES system, except for low collection efficiency when used with the MILES spherically uncorrected f/2.5 plano-convex lens.

This was corrected by mounting the lens with the flat surface toward the diode, making more effective use of those portions of the lens near the perimeter of the aperture.

Once the multihet diodes had been proven for MILES, an order for the entire MILES ED quantity of both three and six-mil diodes was placed, along with a back-up order for six-mil single het diodes in case production six-mil multi-hets did not meet requirements.

3.7.2 DEVELOPMENT OF PROCUREMENT SPECIFICATION

The laser diodes, in production, are set at a power level while monitoring the far field pattern out of the optical system. Each diode then has a specific power setting. The fact that each diode has a different operating power level seriously complicates procurement of the diode.

If the final operating power level is unknown during diode procurement, then a procurement document cannot be written which specifies exact testing levels and includes exact temperature compensated drives. Faced with that uncertainty, we have two choices:

a. Specify the diode over all possible MILES operating levels and temperatures using a "standard" set of MILES temperature compensated drive currents, or

b. Specify the diode at one operating level over temperature with a representative MILES temperature compensated drive current, and accept the risk and/or expense at production of using the diode at a different level.

In MILES ED, the second choice was selected and the MILES procurement document now specifies a single representative temperature compensated drive current and requires that diode output be above a minimum level over the temperature range when that curve is applied. This has resulted in a low price for the diode. Transmitter product specifications now allow system power to fall off or increase a factor of two over nominal at the temperature extremes to allow for operating point differences between the "representative" drive current in the diode spec and final power levels. Using these specifications, each MILES weapon has been able to use identical TC networks for multiheterostructure diodes. *

The present spec does not guarantee that ED TC networks will work in future production. However, it is extremely likely that they will. Protection from future diode product changes may be had by lot testing of lasers in a dry box test fixture as described.

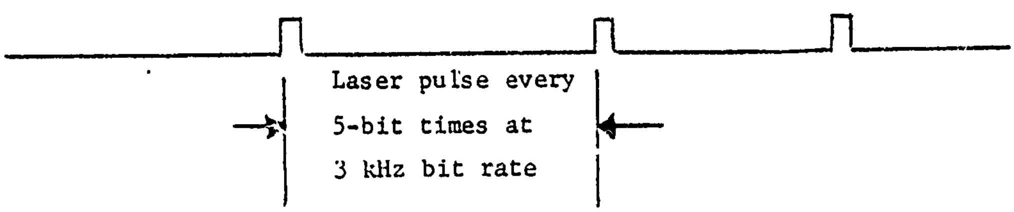
3.7.3 LIFE TESTING AND BURN-IN

We may calculate the amount of time a diode may be operated at 3KHz in order to simulate ten years of MILES use in the field. The weapon firing the most rounds would be a machine gun mounted on a tank. If that machine gun fired 2100 rounds per exercise, and there were 26 exercises per year, and each round contained four kill words and 20 near-miss words, and each word contained six active bits, then the total number of MILES pulses for the ten year lifetime would be $10 \times 26 \times 2100 \times 24 \times 6 = 78.6 \times 10^6$. This equates to a laser pulsed continuously at 3 kHz for 7.28 hours. Thus a MILES laser burned in at 3 kHz for 7.28 hours would equal a lifetime of use. The MILES laser specification calls out a design life of 35 hours minimum at with end-of-life defined as a 20% degradation in power output. The MILES specification requires burn-in of 16 hours at 3 kHz for all diodes.

This may appear excessive compared to the expected lifetime use of a MILES transmitter. However, 16 hours of burn-in are required in order to insure that infant mortality takes place prior to the 7.28 hour lifetime. Hours 17 through 23 are inherently more reliable than any 7 hour period earlier in the diode's life.

3.8 BORESIGHT MODE

The small arms transmitter is designed with a boresight mode. The boresight mode is accomplished by activating the boresight signal (BS*) and the trigger signal (TRIG*) with either the control key or weapon key inserted and engaged, refer to figure 3-1. A 600Hz boresight code is transmitted continuously if above conditions are met.



The boresight mode is employed by connecting a boresight adapter connector. Connecting the adapter activates both the boresight signal (BS*) and the trigger signal (TRIG*) by applying a logic level 0 (ground) to both input ports.

3.9 FIRE INDICATOR

It is desirable to indicate that actuation of the trigger switch, or firing a blank, is causing the unit to transmit a code. The fire indicator has been incorporated to satisfy this need.

This feature is provided on all MILES transmitter simulators other than those mounted on vehicles. A light emitting diode (LED) is caused to illuminate whenever the microprocessor is generating "fire" pulses. The LED is visible to the gunner while firing the weapon in the case of the M16A1 rifle and the machine guns. In the case of the Viper and Dragon, the firing indicator is the decimal point associated with the rounds-remaining display. It should be noted that operation of the "fire" indicator does not guarantee output from the associated laser, but only that "fire" signals are being generated by the microprocessor.

The circuitry required to perform this function is contained within LSI U6 (see figure 3-1). It consists of pulse stretching circuitry and an output stage capable of supplying 20mA to the LED. The pertinent portion of the circuit is shown in fig 3-22 which is typical of all MILES applications.

The input to Q8 is normally held low. When in this condition, C3 is charged through a constant current source delivering nominally 20uA. As a result of the charge on C3, Q10 is on, causing Q11, Q105, Q12 and Q13 to be off, so that no current flows in Firing Indicator CR2. When the brief (5uS) fire pulse is received at the base of Q8, C3 is discharged rap ly and the Firing Indicator is turned on. C3 must now charge to about 0.65V to again turn Q10 on, and the LED off. This charge time is about 1mS and since successive fire pulses occur every 333uS, the LED remains on until the fire pulses stop. Thus, the short fire pulse is lengthened and the LED's apparent brightness is greatly enchanced by this simple pulse stretching.

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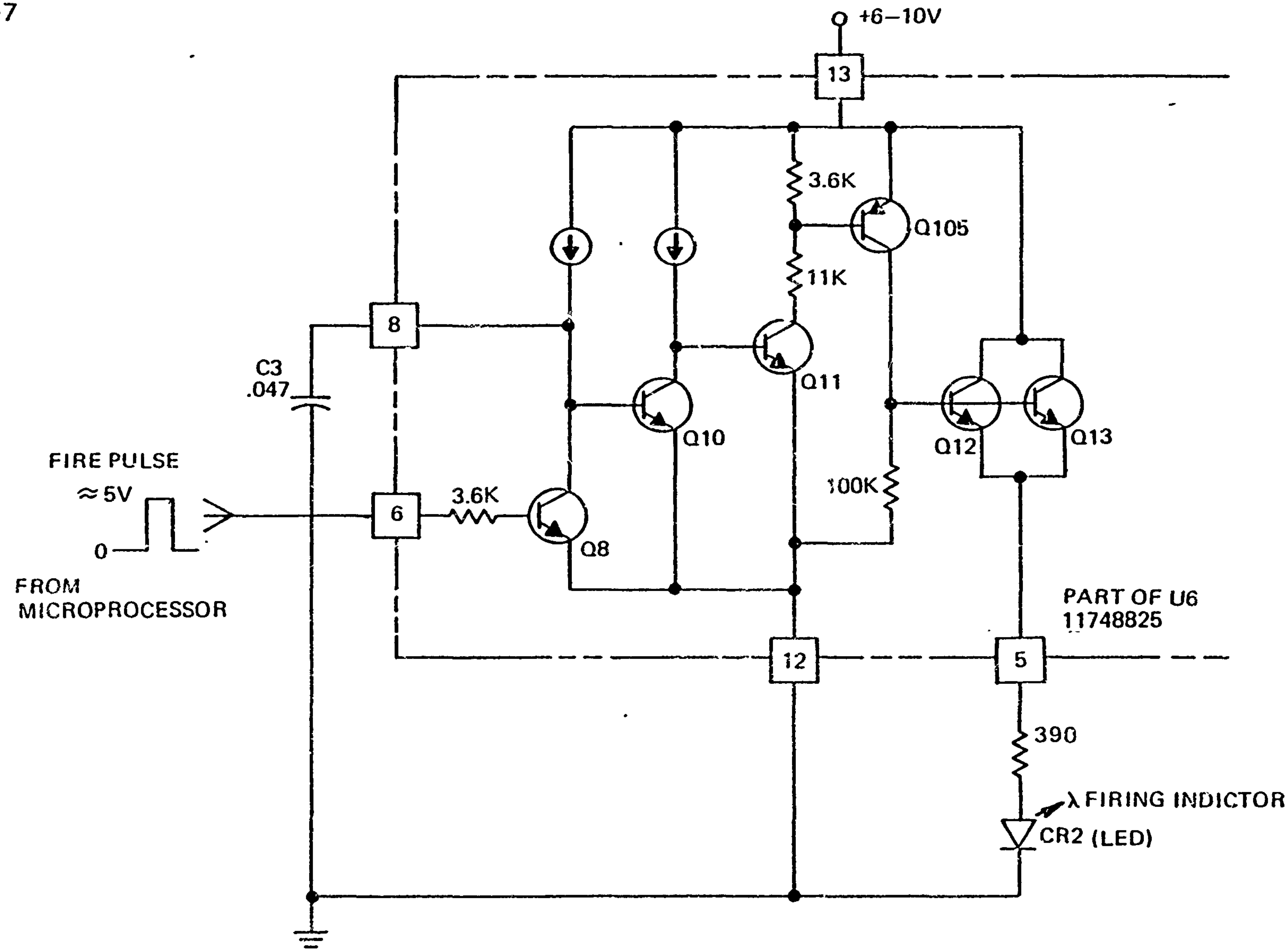

Figure 3-22. Firing Indicator Circuitry

3.10 DRY FIRE ROUND CONTROL

The small arms transmitter is designed with two operating modes of fire:

a. Blank Fire Enable

b. Dry Fire (Silent Fire)

In the Blank Fire Enable mode of operation, the possible number of rounds fired is the actual number of blank ammunition allotted to the operator. The rate of fire is the actual weapon rate of fire. In the Dry Fire mode of operation, round count is controlled by the software program. Refer to table 3-9.

3.11 ROUNDS COUNT INDICATOR

3.11.1 VIPER/DRAGON/TOW

The Viper/Dragon/TOW transmitter is designed with a single digit seven-segment display with decimal point to indicate rounds remaining. The seven segments are driven through 390Ω series resistors by a BCD-to-seven segment latch/decoder/driver chip circuit (U1-Display Driver). The BCD (binary coded decimal) data are inputted by four data lines from the 1802 microprocessor data bus and latched by two gated control and timing outputs from the microprocessor. The number of rounds remaining is controlled by the Viper/Dragon software program. The display is illuminated by depression of the rounds count display momentary switch which is connected to the display blanking input on U1-Display Driver. The display's decimal point is driven through a 910Ω series resistor from the Laser Driver Interface circuit chip and is illuminated when fire pulses are generated to indicate firing (see figures 3-23 and 3-24.

TABLE 3-9

DRY FIRE OPERATION - WEAPON PARAMETERS

	Alloted Rounds	Burst Rate (Rounds)	Transmitted Code Words	Fire Sequence Code Words per Round		Firing Rate (rpm)
				Automatic	Semi-Automatic	
M16 Rifle	210	30	Hit Code #27 Miss Code #29	4 Hit Words, 20 Miss Words	4 Hit Words, 128 Miss Words	678
M60 Machine Gun	600	30	Hit Code #27 Miss Code #29	4 Hit Words 20 Miss Words	N/A	678
M2, M85 Machine Gun	1200	30	Hit Code #24 Miss Code #29	4 Hit Words, 20 Miss Words	N/A	678

For all modes
of operation

3.11.2 LCA

The LCA and CIA electronics assemblies are designed with a front panel two-digit, seven-segment display. The segments are driven through 910Ω series resistors and N-P-N transistor array circuit chips (U7 and U6) by two BCD-to-seven-segment latch/decoder/driver circuit chips (U5 and U4) (see figure 3-23). The BCD data are inputted by 8 data lines and from the 1802 microprocessor data bus. The data are latched by a gated timing signal and the appropriate control signal from the 1802 microprocessor. The control signal is dependent upon the desired display function which is selected by a front panel switch (see figure 3-24). The data displayed, rounds remaining, self-test, etc., are controlled by the LCA and CIA software program. The front panel display is illuminated by the depression of the press-to-read momentary switch located on the front panel. The momentary switch provides a closed path to ground for the common cathode digit display.

3.12 ATWESS TRIGGER CIRCUITRY

ATWESS is fired by actuating a solenoid which releases a sear. This allows a spring-loaded firing pin to impact a primer in the cartridge. A safe-arm mechanism inserts a plate between pin and cartridge when the device is placed in the safe position. The solenoid is fired from a storage capacitor which is recharged after firing.

ATWESS trigger circuitry is designed to prevent TOW, Dragon, and Viper gunners from fighting a "silent war." Care is taken to insure MILES cannot be fired without ATWESS firing also.

In order to do this, a microswitch is included in the safe-arm mechanism to close a circuit only when ATWESS is in the "armed" position. In series with this microswitch are two point contacts which engage a copper disc on

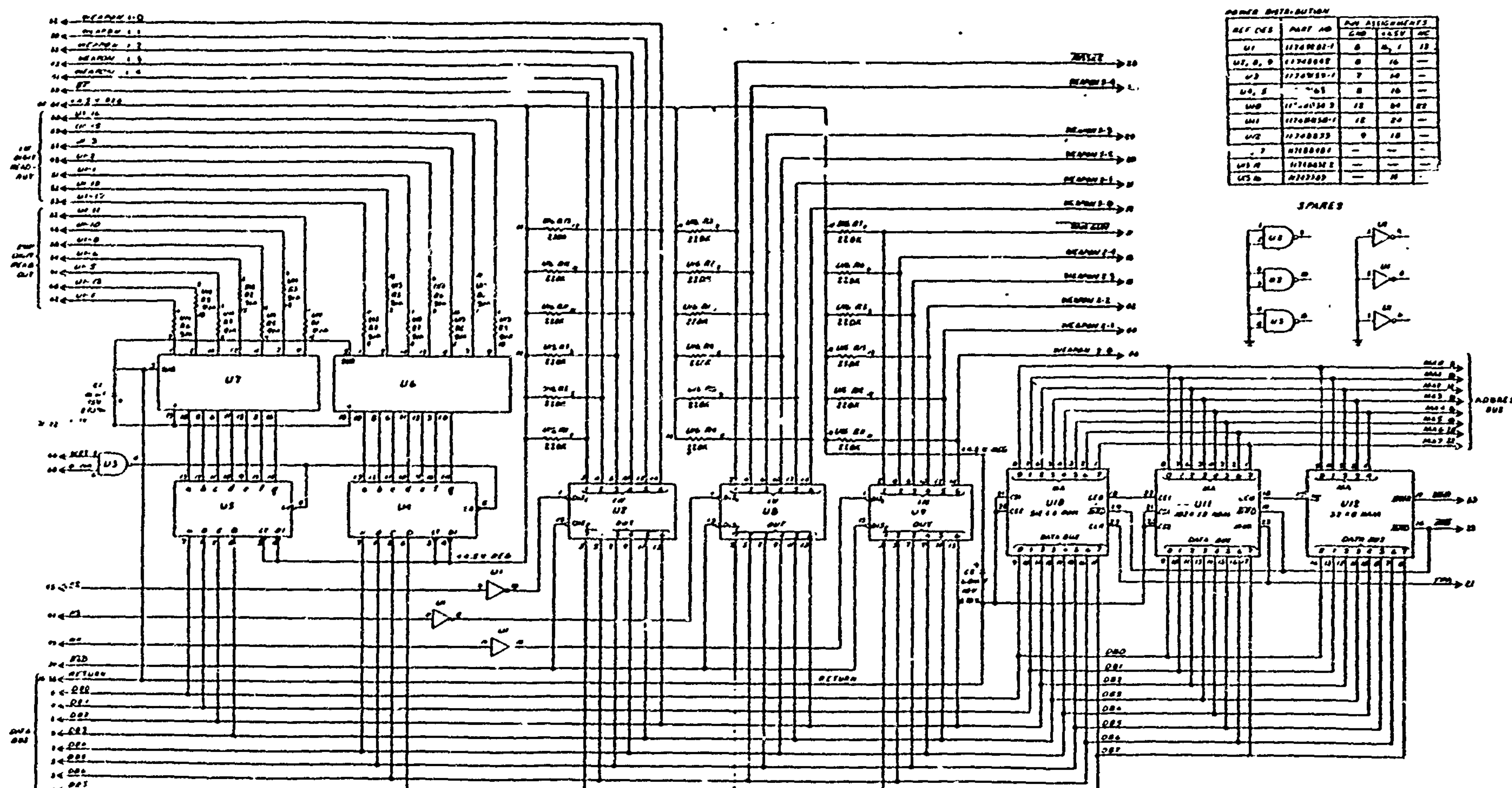

Figure 3-23. Weapon ID and Display Logic Diagram

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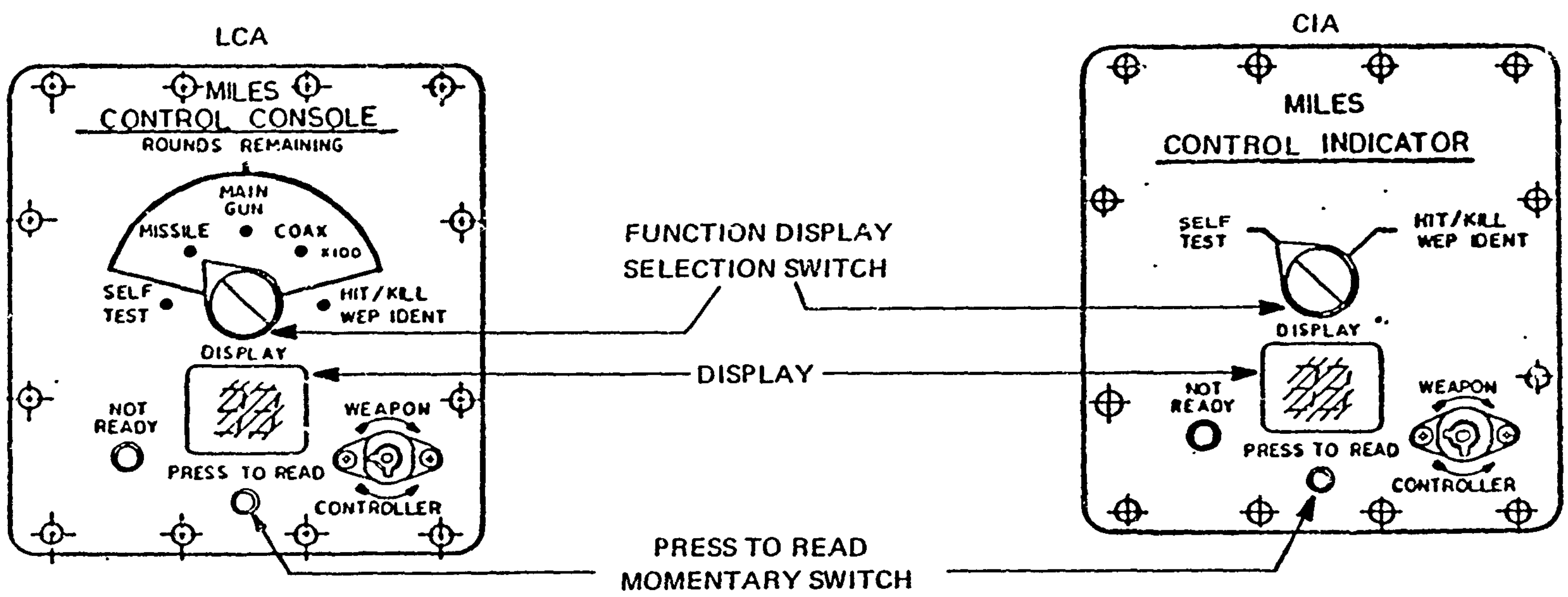

Figure 3-24. LCA and CIA Front Panel

Each unfired ATWESS cartridge. When the cartridge is fired, the disc is destroyed, opening the circuit. When used with ATWESS, MILES may only be fired when a live cartridge is in the ATWESS chamber and the ATWESS safe-arm mechanism is in the armed position.

Figure 3-25 shows the schematics. The logis is the same on all three applications. MILES will receive trigger signals when the weapon trigger is pulled and either of the following two conditions is true:

a. The safe-arm lever on ATWESS is in the "armed" position and a live cartridge containing the conductive disc is in the ATWESS.

b. The controller key switch is in the "dry fire" position.

The Boolean equations defining the logic follow:

$$M = (\bar{S}C + D)\ T = (\bar{S}C)\ T$$

where:

- A = ATWESS electrical trigger signal assertion
- M = MILES electrical trigger signal assertion
- $\bar{S}$ = unsafe or "armed" position of the ATWESS arming lever, as detected by a microswitch in the safe-arm mechanism
- C = presence of an unfired ATWESS cartridge in the ATWESS, as detected by continuity through the copper disc on the cartridge
- D = dry fire position of the controller key-actuated switch
- T = weapon trigger actuation

The following facts regarding ATWESS safety are pertinent:

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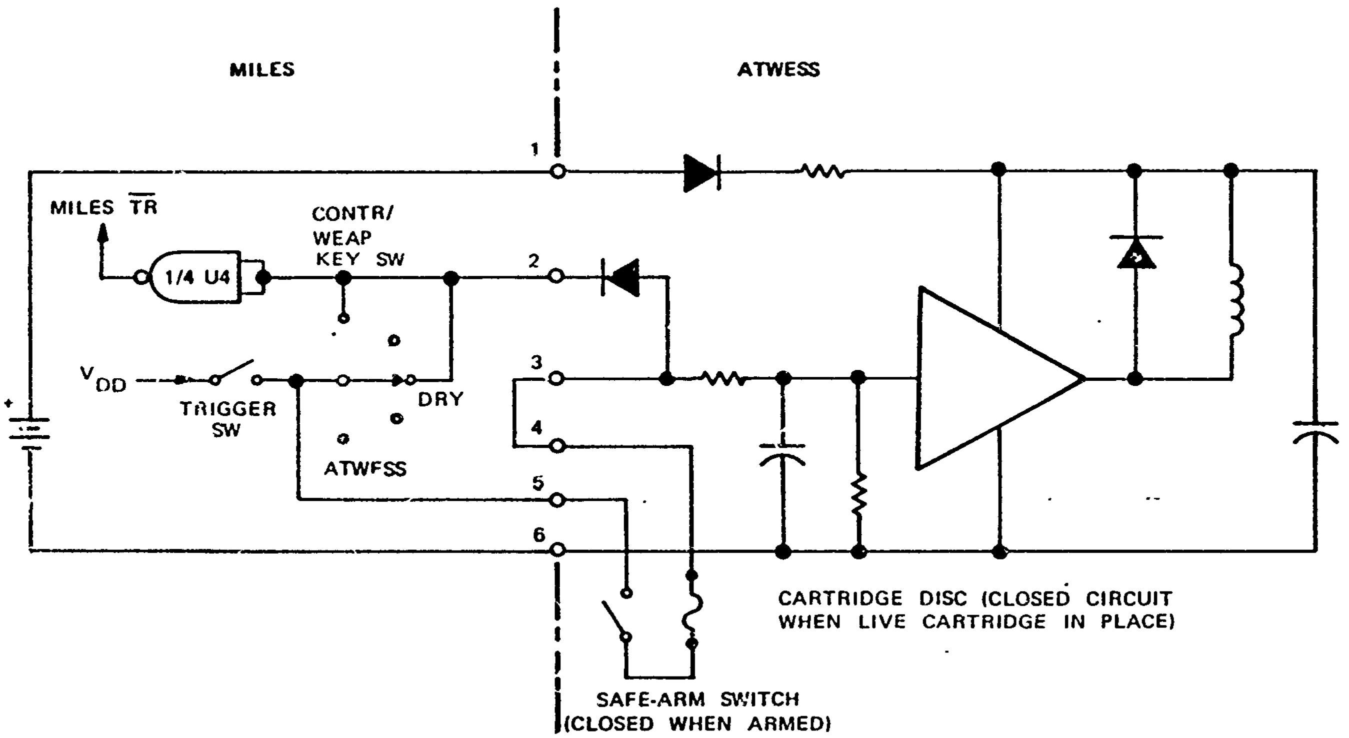

Figure 3-25. Typical MILES/ATWESS Interconnection

a. The large storage capacitor in ATWESS will remain charged and ATWESS will remain dangerous for some time after the MILES ATWESS connector is disconnected. During this time a positive signal on the ATWESS trigger pin of the connector will release the sear on ATWESS regardless of safe-arm lever position. (A mechanical safety will prevent cartridge detonation if the lever is in the "safe" position.)

b. Although MILES requires a weapon key or controller key to enable firing, ATWESS does not. Therefore, ATWESS may fire even when the MILES transmitter is not key-enabled.

In addition to the foregoing safety considerations, it should be noted that the MILES transmitter will fire even though a "dud" ATWESS cartridge is in place.

3.13 ATWESS ELECTROMECHANICAL INTERFACE

ATWESS receives its power and its trigger signal from MILES. It was initially designed to work with Viper, Dragon, and TOW simulators and, since the first two devices use a negative trigger signal, ATWESS was designed to use the same trigger polarity. This caused safety problems which were solved by using a positive trigger signal.

Figure 3-26 shows the very simple circuitry involved. A large electrolytic capacitor (36,000 μF) is charged from the MILES battery through CR2 and R1, storing energy which later will be expended in the solenoid resulting in firing the ATWESS cartridge. The manner in which this is accomplished will be described below.

3.13.1 CIRCUIT OPERATION

The MILES trigger signal is low until the trigger is actuated. Thus, since the trigger signal is applied at pin 2 of the terminal board, Q1 is normally on. As a consequence, Q2, O3, and Q4 are off and the

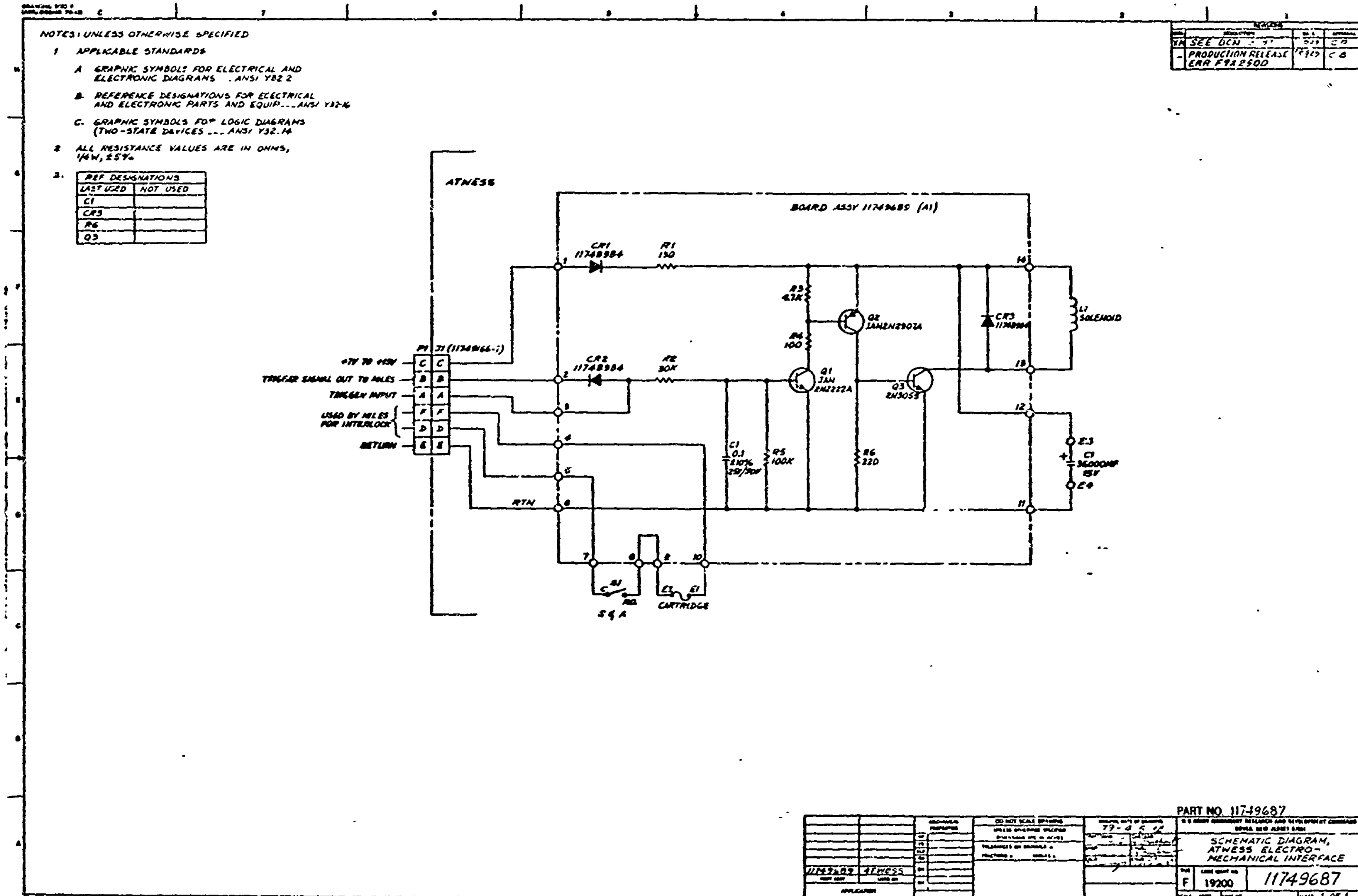

Figure 3-26. ATWESS Electromechanical Interface Schematic Diagram

electrolytic capacitor remains charged. When the trigger signal goes to ground, Q1 is turned off. As a consequence, Q2, Q3, and Q4 are turned on allowing the electrolytic capacitor to discharge through the solenoid with a peak current flow of about 4 amperes. At this point, if it is assumed that the ATWESS has been cocked and armed, the solenoid will pull back the sear, releasing the hammer which then strikes the firing pin and fires the cartridge. C2 has been introduced to avoid expected problems with excessive contact bounce in the trigger switch since the presence of C2 makes a regenerative loop around Q1 and Q2 keeping Q1 off after the first trigger pulse until the solenoid has actuated.

3.13.2 SAFETY DEVICES

In addition to the mechanical safety features incorporated into ATWESS, three electrical safeguards exist. These are the safe-and-arm switch, the cartridge fusible link, and the series trigger diode CR2. The major function of the first two features is to prevent firing of MILES unless ATWESS is armed and a cartridge inserted. As described in subsection 3.13, this feature is incorporated when the MILES system is operated in the ATWESS mode. In order to operate MILES without ATWESS, a "dry fire" mode of operation is selectable by means of the controller key. This position feeds a trigger signal to MILES only. The signal is blocked from ATWESS by CR1.

3.13.3 CONTEMPLATED ATWESS MODIFICATIONS

During OT II testing, several difficulties arose connected with the use of the ATWESS, which have resulted in some design changes to the electronics. Among these difficulties were the following:

a. ATWESS would fire when battery power to MILES was removed.

b. ATWESS would fire if its trigger lead was shorted to ground.

c. In TOW, ATWESS would fire if the bridge clamp lever was moved to the "safe" position.

In each case, the action resulted in a low signal being placed on the trigger lead which was interpreted by ATWESS as a normal trigger. In order to alleviate this difficulty, it was decided to modify ATWESS so that a positive trigger would be required. Essentially, this was accomplished by removing Q1 from the circuit so that the trigger signal connects to the base of Q2. In addition, the safe-and-arm switch and cartridge fusible link are placed directly in series with the ATWESS trigger lead so that ATWESS will not receive a trigger unless armed nor will MILES fire. These changes have eliminated the electrical problems found during OT II testing and they are incorporated in future ATWESS units.

3.14 RECEIVER

The MILES receiver amplifies the signals resulting from coded transmitter pulses impinging upon a group of detectors. It then passes the amplified signal through a threshold circuit the output of which responds only to signals which are above the predetermined threshold. The resulting uniform train of pulses may then be decoded by subsequent circuitry discussed in subsection 3.17. The following paragraphs of this section explain the operation of the MILES detection/receiver circuitry.

3.14.1 DETECTORS

MILES employs a group of parallel connected silicon photovoltaic detectors (solar cells) to detect the presence of laser radiation from the transmitter. The number of detectors connected to a single

amplifier varies from four to eight depending upon the application. The number of detectors employed in a given case is determined by the particular requirements that the detector assemblage cover a specific area and range of directions from which signals might arrive.

The individual detectors have a nominal area of 1 cm^2. They are mounted in a hermetically sealed metallic housing having a glass window. In addition to providing mechanical protection for the detectors, the housing, together with a conductive grid on the inside of the glass window, provides shielding against impinging EMI. A visible light filter eliminates much solar background radiation while admitting infrared laser pulses.

3.14.2 PREAMPLIFIER

The preamplifier/threshold circuit is shown in figure 3-28. Three amplifier stages precede the threshold circuit and serve to amplify the signal appearing across the detectors to an amplitude of about 0.25 volt or more. The threshold circuit then can differentiate between signal and noise pulses based upon the greater amplitude of the signal pulses. This section will describe the preamplifier portion of the circuit.

The first and third amplifier stages are similar in design and consist of inverting negative-feedback gain-stabilized amplifiers. The second stage is noninverting but is also gain-stabilized by negative feedback. The first and second stages are incorporated in LSI U1 of figure 3-27 and the third stage and the threshold detector are incorporated in LSI U2. A simplified circuit is shown in figure 3-28.

The signal from the group of parallel connected detectors is coupled to the input of the first amplifier stage through pulse transformer T1 and coupling capacitor C8.

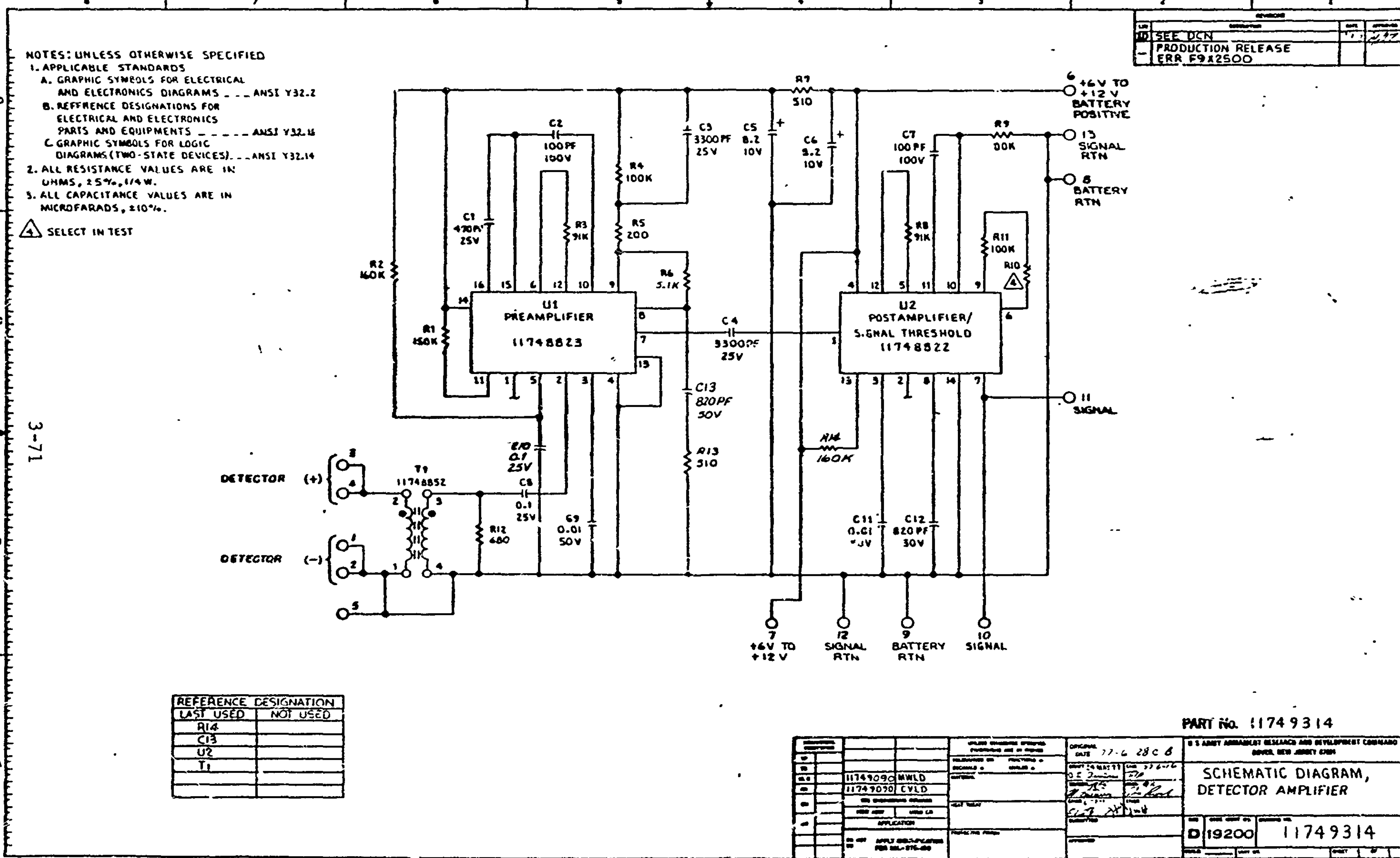

Figure 3-27. Detector Amplifier Schematic Diagram

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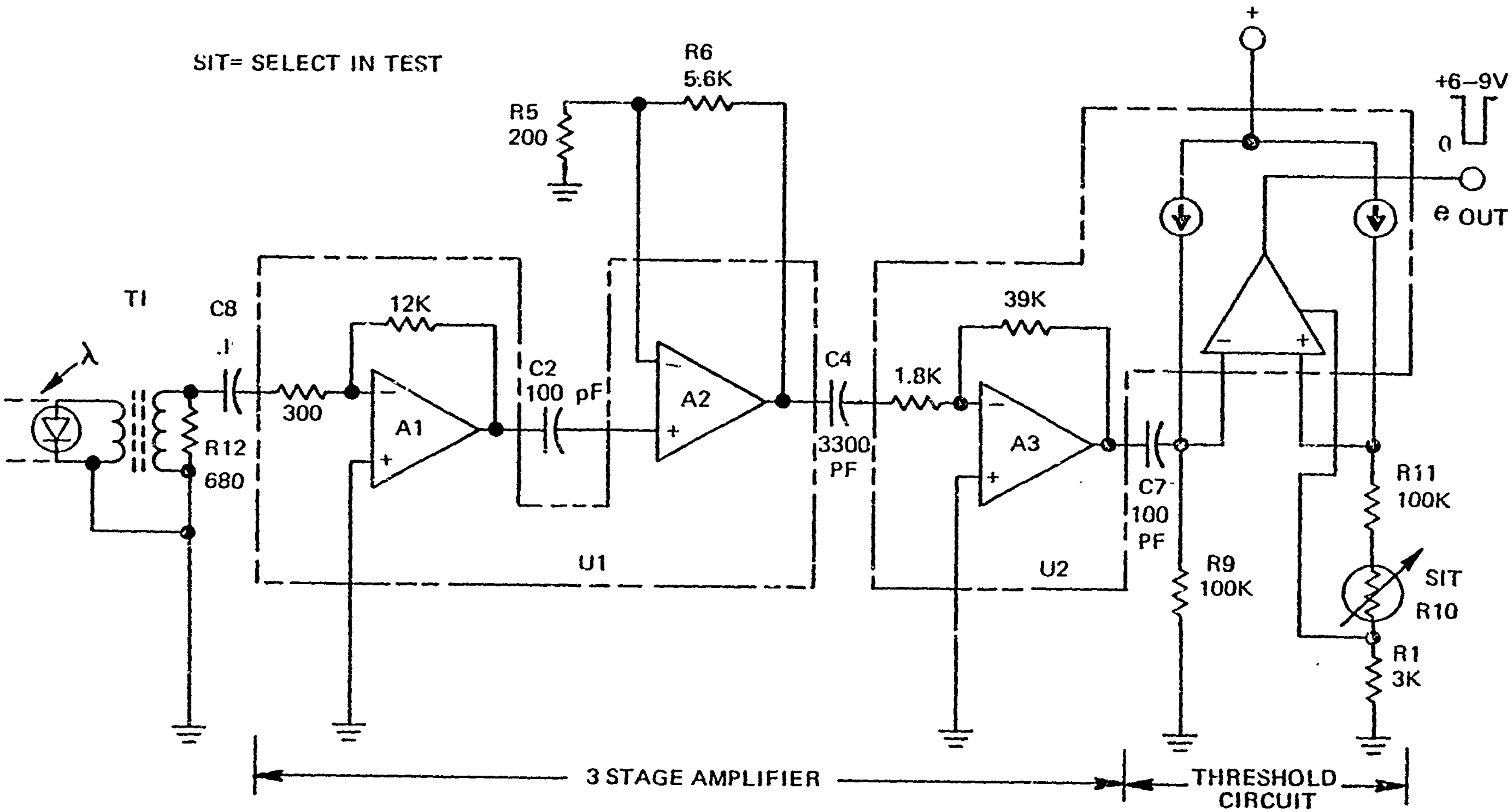

Figure 3-28. Simplified Schematic Preamplifier/Threshold

The amplifier section provides a total gain of about 15,000 and a bandwidth extending from about 100 kHz to about 1.5 MHz. The worst case input noise-equivalent-energy with eight detectors is about 7 μergs. A primary consideration in preamplifier design was that it should have low power consumption to insure good battery life. Total current drain including threshold circuit is approximately 1 mA.

The low frequency rolloff is determined by the response of the input transformer and the interstage coupling capacitors. The high frequency limitation is brought about by the combination of parasitic capacitances in the LSI circuits and the limited gain-bandwidth of the LSI transistors at their necessarily low operating currents.

3.14.3 THRESHOLD CIRCUIT

The output of the three stage amplifier contains both signal pulses and noise pulses. Noise originates mainly from two sources, the input stage of the first amplifier and from sunlight-induced current flowing in the detectors. It is the function of the threshold detector to separate the desired signal pulses from noise pulses based upon the difference in their respective amplitudes. Since any noise pulse which reaches the threshold level will be accepted as a valid signal, it is important that the threshold be set high enough so that relatively few noise pulses reach this amplitude. It has been calculated that about 90 noise pulses per second may be accepted without an excessive false kill rate in the man worn system and a somewhat higher number in the vehicle systems. The threshold level is regularly set to accept no more than 30 noise pulses per second under worst case conditions so as to provide a significant safety factor.

The threshold detector consists of a simple balanced amplifier. Bias for the amplifier is obtained from two resistors, R9 and the series combination R11, R10, and R13. In this latter group, R10 is selected

in test to set the threshold level. Current is supplied to these resistors by two matched constant current sources housed within LSI U2. R13 is a hysteresis resistor which is short circuited during a pulse in order to provide more reliable triggering of the threshold circuit with marginal signal levels.

The output of the threshold detector is a single negative pulse approximately 10 μsec long for each input pulse which is above the threshold level. This output signal is then fed to the subsequent logic circuitry which performs the task of code recognition.

3.14.4 THRESHOLD ADJUSTMENT

The selection of R10 to set the threshold level was mentioned in the preceding subsection. At the present time, the selection of R10 is accomplished by feeding noise into the amplifier from a group of standard detectors irradiated by simulated sunlight. The noise resulting from this sun current together with amplifier noise then appears at the threshold input. The normal operating current of U1 is increased to simulate worst case (low temperature) performance by shunting the current set resistor for U1, R3 of figure 3-27. The value of R10 needed to give a count rate of 20 to 30 pulses per second less is then determined and compared with the expected range of values. The actual R10 used is an empirically determined value obtained by exposing a detector with the desired energy density of laser signal of about 25 μergs per pulse. In this way, close control of receiver sensitivity is maintained.

3.15 INDUCTIVE LOOP

In the man-worn detection system, it is necessary to have an array of detectors on the helmet as well as the torso since the head is the most frequently exposed, vulnerable portion of the body. Since it is

undesirable and, in fact, unsafe to have a wire connection between the helmet and the harness, a scheme has been developed to transmit helmet signals to the torso harness without a wire connection. This scheme involves a loop of wire around the helmet which is used to transmit the helmet signal to a similar loop at the shoulders of the user, the shoulder loop being connected to a receiver which then sends the coded signal to the decoder in the harness electronics. This arrangement is the inductive loop which is described in this section.

3.15.1 TRANSMITTER (HELMET)

The helmet transmitter contains a preamplifier-threshold circuit which is identical to that used to detect coded laser signals for the torso electronics and vehicle belts as described in subsection 3.15. This circuitry is followed by an additional circuit, however, which causes a pulse of current to flow in the helmet loop each time a laser pulse is detected by the preamplifier-threshold circuit. This action is produced by a silicon controlled rectifier (SCR). A capacitor is charged to the battery voltage. When a pulse is received, the SCR is fired. The SCR acts like a fast switch which connects the charged capacitor across the single turn helmet loop. The sudden current pulse produces a magnetic field which is sensed by the receiving loop associated with the torso or harness electronics. Charging of the capacitor and firing of the SCR is repeated for each received laser pulse.

3.15.2 RECEIVER (TORSO)

The two-turn receiving loop, lying on the user's shoulder, is completed in the harness by means of a cloth strap which contains the wires forming the loop and crosses the chest. The loop is tuned to about 1 MHz which corresponds to the nominal resonant frequency of the transmitting loop described above.

The sudden pulse in the magnetic field caused by the helmet transmitter induces a voltage into the receiving loop. A threshold circuit, very similar to that used in the receiver, is used to sense the voltage across the loop and to produce an output pulse when the voltage exceeds the threshold. This output is "or-ed" with the output of the harness preamplifier-threshold before being fed to the decoder so that signals striking either helmet or harness or both may be detected.

3.15.3 SENSITIVITY ADJUSTMENT

It is necessary to adjust the loop receiver sensitivity in order to avoid undesired response to noise. This is accomplished in much the same fashion as the receiver threshold adjustment. A fixed resistor is selected in test so that the reference voltage for the threshold circuit is set to cause the circuit to trigger at the desired level.

The major sources of noise are various forms of EMI. These can come from radio transmitters, automotive ignition, and similar sources. The resonant frequency chosen for the receiving loop is in the AM band. Hence, it is unlikely that large field strengths would be encountered in an area where training was being conducted. High frequency radios, such as might be used for military communication, will not produce large loop voltages. There are two reasons for this. First, these signals occur at frequencies far removed from the resonant frequency of the loop. Second, the leads from the loop pass through feedthrough capacitors which serve to strip off undesired signals before they reach the threshold circuit. Most lower frequency signals are eliminated by the appropriate setting of the receiver sensitivity as described above. In this way it is possible to maintain reasonable sensitivity to desired signals while effectively rejecting undesired signals.

3.16 DECODER

3.16.1 MAN WORN LASER DETECTOR (MWLD)

The basic component of the MWLD decoder is a custom-designed CMOS digital LSI circuit (refer to figure 3-29). The basic clock rate for the MWLD decoder is 48KHz which is generated by a clock oscillator incorporated in LSI design in conjunction with a 48KHz crystal. Code reception consists of a data signal received from 8 solar detectors mounted on the body harness, or a conditioned data signal (loop signal) received from 5 solar detectors mounted on the helmet. Codes transmitted from weapons are 11 bits long (weight 6) at 3 KHz, with active bits of 1 to 8 μsec duration at the decoder input. The decoder samples and shifts the incoming data through two serial shift registers at a 48KHz rate. Boolean union decoding takes the union of incoming bits with bits from the previous word. This is accomplished by taking the logic "OR" of the output of the first shift register with the incoming data and feeding it to the input of the second serial shift register. Eleven taps spaced every 16 bins through the second serial shift register are continuously monitored.

A 5-bit up/down counter keeps track of the total number of active bits shifting through the second serial shift register, and resets the shift register to all nonactive bits if 32 or more active bits are accumulated.

From the 11 taps, the MWLD decoder has the capability of decoding 8 different codes, 6 hit codes-code #00, #21, #22, #23, #24, #27, and 2 miss codes-#29, #20. Nine data lines of which one is a gated combination of 3 data points are brought to the LSI output pins for use in the LCA and CIA decoder electronics section. When either of the

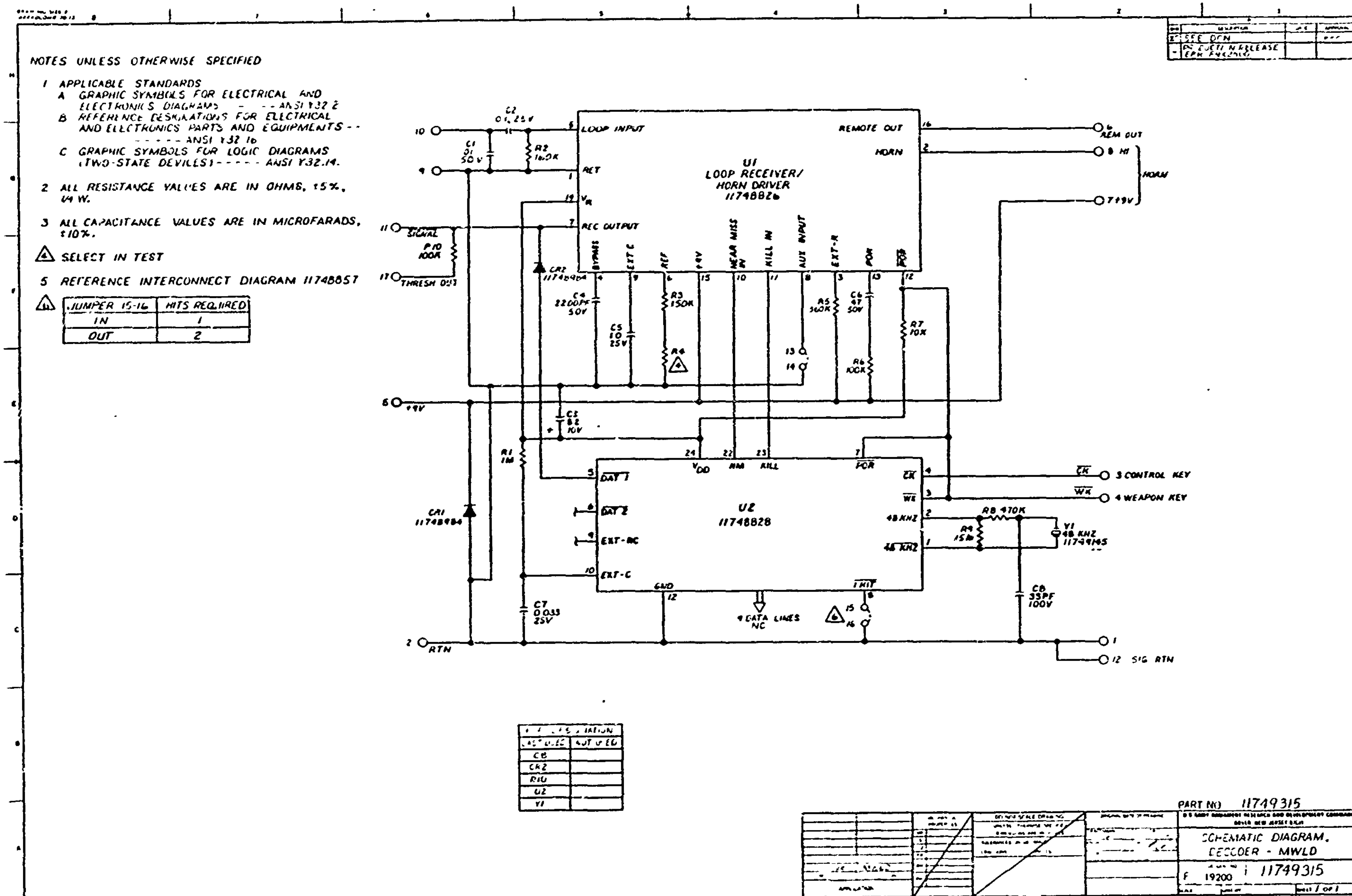

Figure 3-29. MWLD Decoder ıematic Diagram

two miss codes is decoded the LSI circuit generates a miss signal which is outputted to the Loop Receiver/Horn Driver circuit chip (U1, Dwg. #11748826) which in turn activates the buzzer (horn) for approximately 0.5 second. Decoding any one of the 6 hit codes sets the kill latch in the LSI circuit. Also at power turn on, a power on reset signal (POR*) generated in U1 sets the kill latch. Additionally, if the weapon key is inserted and engaged before an actual kill the kill latch is set. The kill latch is only reset when the control key is inserted and engaged. When the kill latch is set without the weapon key inserted and engaged, a continuous active kill signal is outputted to U1 which in turn activates the buzzer (horn) continuously.

3.16.2 LCA AND CIA

The decoder in the LCA and CIA is designed to decode up to 32 different MILES codes (refer to figure 3-30). Code data is received from the vehicle detection belts and inputted into a MWLD decoder LSI (U5). The decoder LSI circuit samples and shifts the data and outputs the nine data lines as stated in Section 3.16.1. The nine data lines are used as address lines to the valid code ROM (Read Only Memory), U14. When one of the 32 codes is received, the valid code ROM with additional timing signals strobes a 6-bit identification data code into an input data port (U15) which in turn interrupts the 1802 microprocessor to signal that a valid code has been received. The 1802 microprocessor, under program control, accepts identification data code and clears the input port to allow reception of the next valid code. The software program processes and analyzes the identification data code to determine the transmitted weapon's lethality against the Vehicle (LCA or CIA).

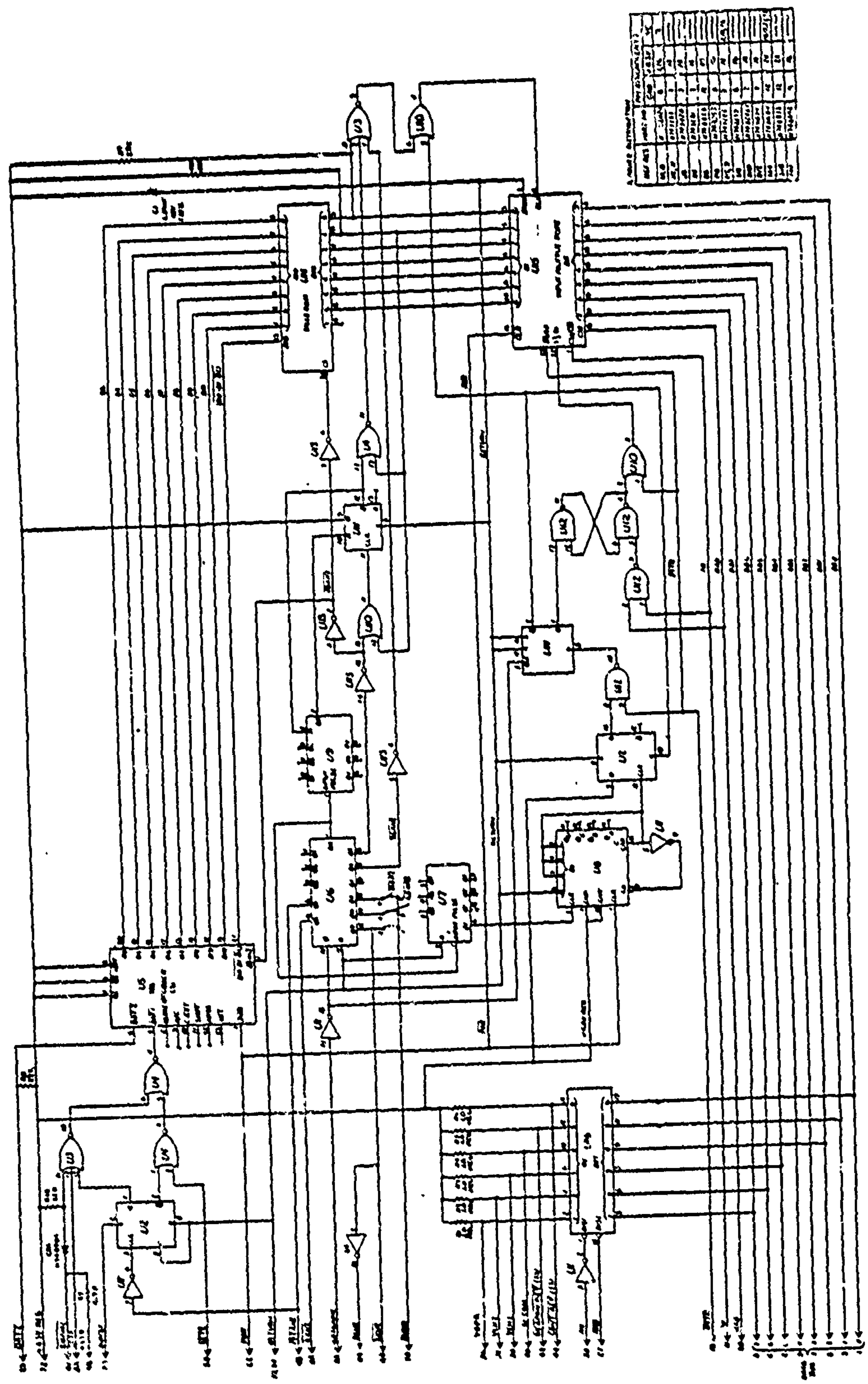

Figure 3-30. Decoder Logic Diagram

3.17 VEHICLE KILL PROBABILITY

The microprocessor structured electronics in the Loader's Control Assembly (LCA) and the Control Indicator Assembly (CIA) receives incoming MILES coded weapon hit signatures and then, based upon the weapon/target relationship, performs a decision of hit or kill based on predetermined first round kill probabilities. The kill probability is assessed after each "hit detection". For vehicle systems (LCA and CIA) a hit or miss detection consists of receiving two identical code words within a variable window time of 128msec to 256msec, with the window time starting at the reception of the first code word. An exception to this, is the reception of tracking missile weapon codes where a hit detection requires the reception of 22 to 32 missile code words and a miss detection, 2 to 21 words within a ten second window time with the window time starting at the reception of the first missile code word.

In the MILES weapon array there are many weapons that transmit more than 2 hit code words per round, example - 105 mm main gun transmits 8 hit code words per round. Thus for an 8 hit word coded "round", the kill probability is exercised 4 times if all 8 hit code words are received. Therefore, the vehicle kill probabilities stored as ROM data constants for weapons that transmit more than two hit code words per round are less than the first round kill probabilities. The accumulated effect if all words are received is equal to the first round kill probability. Refer to "Vehicle Kill Probabilities" (table 3-10).

The probabilities are related as follows:

$$P_R = 1-(1-P_D)^{[(N+1)/2]}$$

where

TABLE 3-10

KILL PROBABILITIES

CODE NO.	WEAPON	HIT WORDS PER ROUND	KILL PROBABILITY PER ROUND VEHICLE TYPE: TRUCK/JEEP	AC/HELO	APC	TANK
00	100% Univ. Kill	16	100.0%	100.0%	100.0%	100.0%
01	Maverick	8	100.0%	100.0%	100.0%	100.0%
02	Hellfire	M	100.0%	100.0%	100.0%	93.75
03	Sagger	M	100.0%	95.3125	98.4375	70.3125
04	60 mm, 81 mm, 4.2 inch	8	100.0%	100.0%	73.4375 / 28.125	1.5625 / 1.5625
05	M15A Mine (Track Cutter)	4	100.0%	100.0%	98.4375 / 87.5	98.4375 / 87.5
06	Weapon X	8	100.0%	100.0%	No Effect	No Effect
07	TOW, SHILLELAGH	M	100.0%	98.4375	100.0%	85.9375
08	DRAGON	M	100.0%	100.0%	98.4375	76.5625
09	M202 Flame	4	100.0%	100.0%	62.5 / 39.0625	78.125 / 53.125
10	M21 Anti-Tank	4	100.0%	100.0%	100.0%	79.6875 / 54.6875
11	Claymore M18A1 & M16	4	85.9375 / 62.5	78.125 / 53.125	No Effect	No Effect
12	105 mm	8	96.875 / 57.8125	100.0%	96.875 / 57.8125	87.5 / 40.625
13	152 mm	8	96.875 / 57.8125	100.0%	100.0%	78.125 / 31.25
14	2.75 in. Rocket	8	96.875 / 57.8125	92.1875 / 46.875	78.125 / 31.25	42.1875 / 12.5
15	VIPER	8	96.875 / 57.8125	92.1875 / 46.875	81.25 / 34.375	48.4375 / 15.625
16	120 mm	8	96.875 / 57.8125	100.0%	100.0%	93.75 / 50.0
17	90 mm	8	96.875 / 57.8125	100.0%	90.625 / 45.3125	34.375 / 9.375
18	8 inch, 105 How, 122 mm, 155 mm	8	96.875 / 57.8125	100.0%	95.3125 / 53.125	1.5625 / 1.5625
19	Grenade (40 mm)	8	56.25 / 18.75	84.375 / 37.5	10.9375 / 3.125	4 6875 / 1.5625
20	Rockeye (CB)	2	81.25	81.25	15.625	20.3125
21	Bushmaster (25 mm), GAU-8, AH (30 mm)	2	84.375	43.75	9.375	6.25
22	ZU23-4	2	43.75	50.0	6.25	No Effect
23	Vulcan (20 mm)	2	43.75	23.4373	6.25	No Effect
24	M2, M85 (50 CAL)	4	37.5 / 20.3125	4.6875 / 3.125	4.6875 / 3.125	No Effect
25	Chaparral	8	No Effect	96.875 / 57.8125	No Effect	No Effect
26	Stinger	8	No Effect	9[illegible].1875 / 46.875	No Effect	No Effect
27	M16, M60, Coax (7.62 mm)	4	9.375 / 4.6875	3.125 / 1.5625	No Effect	No Effect
28	Heavy Weapon Miss	—	Miss	Miss	Miss	Miss
29	Light Weapon Miss	—	Miss	Miss	Miss	No Effect
30	Light Weapon Miss Spare	—	Miss	Miss	Miss	No Effect
31	Heavy Weapon Miss Spare	—	Miss	Miss	Miss	Miss
Code No.	0 thru 27-Hit Codes	M = Missile		Kill Probability		

Kill Probability: Per Round / Per 2 Code Words Received

P_R = first round hit probability

P_D = probability stored in ROM

N = number of words transmitted

[ ]= largest integer in the argument

The kill probability function is under the control of the microprocessor software program and is accomplished by comparing the ROM stored weapon versus vehicle kill probability data with a number generated from a random number generator. The random generator is an internal microprocessor scratch pad registor set aside for this function only. The random number generator register is continuously incremented by one during all slack periods, and multiplied by the constant 19 after each hit detection not resulting in a kill for the generation of a random number.*

3.18 AUXILIARY OUTPUT FROM MWLD

The TES MWLD decoder is designed with an auxiliary output (signal "Remote") which is generated in conjunction with buzzer (horn) drive signal in the Loop Receiver/Horn Driver circuit, U1. Refer to figure 3-29. This signal is active whenever the buzzer (horn) is activated, approximately 0.1 second for near miss and continuous for kill. The use of the auxiliary output is for possible future adaption of TES MWLD decoder to target practice simulation.

3.19 COMBAT VEHICLE KILL INDICATOR (CVKI)

As its name implies, the CVKI is used to indicate to surrounding players that a vehicle has been near-missed, hit, or killed. To that end, it contains an amber strobe light.

*Abramowitz and Stegun: Random Number Generation
Handbook of Mathematical Function, National Bureau of Standards

Figure 3-31 shows the schematic. The strobe light is powered by vehicle 28V power, since it represents an excessive current surge to the MILES batteries. Diode CR2 prevents damage to the strobe light from an inadvertent polarity reversal of vehicle power.

Dip relay, U1, is energized by the $\overline{\text{LITE}}$ signal applied by switching an open collector 2N2222A transistor in the LCA or CIA. When U1 is energized, the strobe light will flash one time. CR1 prevents inductive kickback from the relay coil.

3.20 POWER CONDITIONING

The term "power conditioning" can mean many things, from perhaps the simple filtering of a fluctuating power bus to the generation of voltages quite different from the original souce voltage. In MILES, as in most complex electronic devices, it is necessary to provide filtering on power lines to avoid adverse effects from the high impedance of aging batteries. However, this is quite straight-forward and will not be discussed further here. The present section will concern itself with the methods used to produce regulated voltages to operate certain specialized parts of the circuitry.

3.20.1 MWLD POWER CONDITIONING

The torso electronics contains the CMOS decoder circuitry. This custom LSI cannot operate satisfactorily over the full range of battery voltage because of certain specialized fabrication techniques which were employed. Consequently, although the operating voltage need not be carefully regulated, it is necessary that it be restricted to the range of about four to six volts.

REVISIONS		
SEE DCN78-2447		
PRODUCTION RELEASE ERR F9X2500		

NOTES: UNLESS OTHERWISE SPECIFIED

1. APPLICABLE STANDARDS
   A. GRAPHIC SYMBOLS FOR ELECTRICAL AND ELECTRONIC DIAGRAMS ... ANSI Y32.2
   B. REFERENCE DESIGNATIONS FOR ELECTRICAL AND ELECTRONIC PARTS AND EQUIP ... ANSI Y32.16
   C. GRAPHIC SYMBOLS FOR LOGIC DIAGRAMS (TWO-STATE DEVICES ... ANSI Y32.14

2.

REF DESIGNATIONS	
LAST USED	NOT USED
CR2	
U1	
TB1	

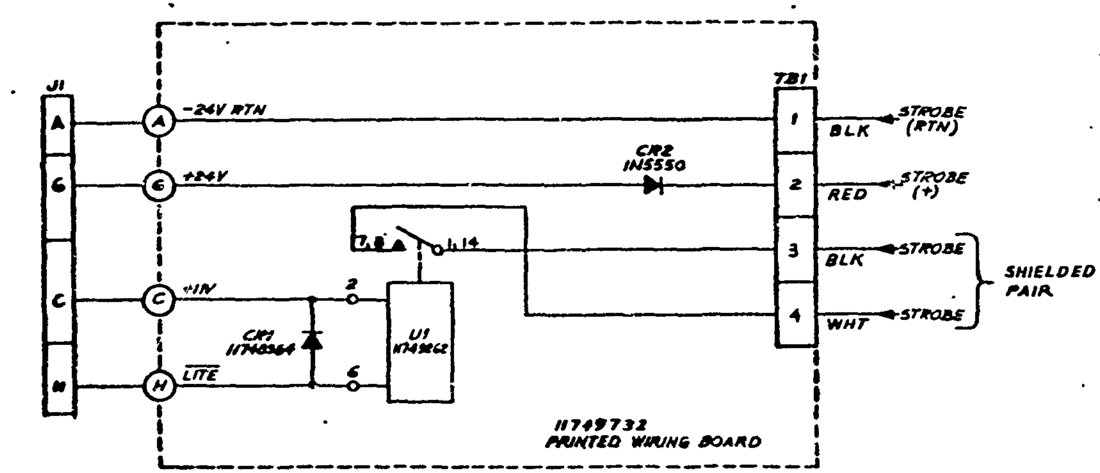

Figure 3-31. Schematic Diagram, Strobe CVKI

PART NO. 11749730

11749728	CVKI
11749732	CVKI
11749720	CVKI

APPLICATION

DO NOT SCALE DRAWING

79-4-10

SCHEMATIC DIAGRAM, STROBE CVKI

D 19200 11749730

SHEET 1 OF 1

The regulating circuit to provide the small required current of about one milliampere is located within the LSI chip known as the Loop Receiver/Horn Driver. It consists of a simple emitter follower, the base of which is held at a reference voltage generated by eight diodes in series. A current mirror delivering about forty microamperes supplies current to both the diode string and the base of the emitter follower. This simple circuit can supply up to two milliamperes at about 4.5 volts at room temperature. Since the CMOS circuitry is not sensitive to voltage changes within the acceptable bounds, no attempt is made at temperature compensation. As a consequence, the output voltage has a temperature coefficient of about - 14mV per degree Celsius. This means that the nominal output voltage will be about 5.2 volts at -31°C and about 4.0 volts at +62°C. Thus the supply voltage for the CMOS decoder is controlled to a satisfactory degree with the additional expenditure of only 40 microamperes of battery current.

3.20.2 INDEPENDENT TRANSMITTERS

A somewhat similar situation arises in the independent transmitters such as the M16A1 rifle, the machine guns, and the Viper, Dragon, and TOW. In these cases several devices require reduced voltage, the primary device being the microprocessor. Again, since the regulated voltage is being provided to CMOS units, its actual value is not very critical so that the temperature coefficient is not of great concern.

In this case, however, a different problem comes to bear on the design. In the case of the Dragon, Viper, and TOW, the rounds count displays must be operated. Since the decoder-latch for these displays must connect to the microprocessor, interfacing is simpler if the displays also operate from the regulated voltage. Hence the load regulation must be good since the load may vary from about 1 mA to perhaps 35 mA if the display is interrogated.

The regulator for the transmitters is integrated into the Laser Driver Interface LSI. In this case a differential error amplifier senses the difference between a portion of the output voltage and a reference voltage generated by two diode drops. The differential amplifier drives a Darlington connected emitter follower to produce the regulated voltage. All of the components including the voltage divider are within the LSI chip. The only external components required are two tantalum capacitors for control of impedance and stability.

Both the emitter and base of the output transistor of the Darlington pair are brought to pins on the chip. Originally, the base terminal pin was provided only to permit connection of a stabilization capacitor. Later, it was learned that the microprocessor tended to be marginal with regard to the required clock rate when at minimum voltage. It was found practical to split the load so that the high current for the display was taken from the emitter terminal of the regulator while the microprocessor and ROM were powered from the base terminal. This provided about 0.7 volt additional for the microprocessor and has helped eliminate any problems with device speed.

The nominal ratings at room temperature are 4.5 V at 40 mA for the high current output and 5.2 V at 3 mA for the low current output. Because uncompensated diodes are used to generate the reference voltage, the temperature coefficient is again about -14 mV per degree Celsius. The regulator circuit in this case requires about 175 μA of battery current. More than one-half of this current is expended in the voltage divider which produces a suitable portion of the output voltage for comparison with the reference voltage. The divider current is also used as a bleeder current so that the regulator remains in its linear region even though the external load current may become very small.

3.20.3 LCA AND CIA

The same regulator employed in the transmitters is used for the LCA and CIA. In this case the higher voltage output is not used and the CMOS circuitry is operated at the nominal 4.5 volt level. This voltage proves acceptable in this more complex case because of higher capacitive loading which eliminates timing problems. These timing problems associated with the microprocessor were the reason that a higher operating voltage was needed for the transmitters where existing parasitic capacitance was lower.

In the case of the LCA and CIA it is unnecessary for the regulator to supply the current for the two digit display. The larger board size makes it practical to arrange the logic-display interface so that current for the display is taken from the raw battery supply.

3.21 CABLING, GROUNDING, AND SHIELDING

The methods used to interconnect MILES units while providing satisfactory EMI performance are described in this section. Two methods are described: portable simulator systems (the MWLD, M16A1 rifle, machine guns, Dragon, and Viper) and the vehicular systems.

3.21.1 PORTABLE SIMULATORS

In all cases, the electronics assembly is mounted in a metal box which is used as the main shielding element. In general, leads external to the housing are twisted and shielded to minimize radiation as well as susceptibility. The housing is the primary ground point for shields as well as the electronic circuitry.

In the case of the MWLD, there are separate detector and horn enclosures. Cable shields are tied to these housings as well as to the main electronics box to complete the shielding. In the case of the MWLD, a conductive gasket is used to seal the cover of the electronics housing.

3.21.2 VEHICULAR SIMULATORS

The problem of shielding and grounding is more complex in the case of vehicles since there are four classes of major assemblies to be interconnected: the detector belts, the control unit, the transmitter assembly and the vehicle kill indicator.

The grounding scheme selected was to use the control unit as the central point at which all circuitry is tied to the vehicle. All other circuits return to the control unit through their cables to reach ground. Cable shields are grounded to the frame of each unit where those units can be isolated from the vehicle. Otherwise the shield is insulated at the remote point. In this way potential differences between various portions of the vehicle cannot cause shield currents to flow, thereby lessening the possibility of coupling vehicle noise into the MILES system. The central system ground is at the control unit. Since vehicle power is used only to operate the vehicle kill indicator and since this power is switched by relays, there is no conductive connection between the vehicle electrical system and MILES.

SECTION 4

HARDWARE DESCRIPTION

4.1 MILES SYSTEMS

MILES currently consists of eleven systems. These systems include infantry, armor, and anti-armor weapons plus three items of operational test equipment: (1) a Small Arms Alignment Fixture (SAAF) for boresighting the M16 Rifle and M60 Machine Gun; (2) a Vehicle System Test Set; and (3) a Controller Gun for checking the detection systems. A 12th MILES system (for the M60A2 tank) was developed but was not procured, however, the MILES design for this tank system is described in this section. Since there is considerable commonality at the assembly and subassembly levels, this section groups systems by their commonality. Rather, the common assemblies are discussed in detail. At the system level, the assemblies are identified and where there are specific system differences they are shown in the system descriptions. The detailed differences are discussed in the subsections that follow.

Table 4-1 is a matrix of the MILES systems showing the common assemblies and quantity of each used in the systems. This matrix is also a key to the assembly detailed discussions that follow the general system descriptions. In the detailed assembly discussions, for example, transmitters are discussed in two basic categories; [1] dependent transmitters, and [2] independent transmitters. Within these basic categories, the differences between various laser transmitters are described.

The MILES systems and their basic tactical operational scenarios are first summarized and then the key assemblies are described in detail. Other operational aspects of the system, such as weapon hierarchy, weapon simulation, and safety, are also discussed as general subjects rather than treated with each weapon system.

4.1.1 SIMULATOR SYSTEM, FIRING, LASER: M60 For M16A1 RIFLE (MILES DEVICE A17A60)

System description

The A17A60 M16A1 rifle system, shown in figure 4-1, consists of one each of the following items:

a. Laser Transmitter, M16A1 rifle, 5.56 mm

b. Weapon Key (yellow)

c. Laser Detector, Man Worn (MWLD)

Tactical Scenario

- The infantryman is killed by any weapon in the MILES hierarchy.

- A kill sets off the hit indicator alarm on the MWLD harness.

TABLE 4-1

ASSEMBLY COMMONALITY AT SYSTEM LEVEL

Assemblies	(4.4) Detectors/Hit Indicators								(4.2, 4.3) Transmitters									Organization Checkout	
		(4.4.2) (4.4.2.1) CVLD Belt Segments				(4.4.2.2) Control Console			(4.2) Independent Laser Xmtrs				Spl. Packaging			(4.3) Dependent Laser Xmtrs			
(Sec. 4.1) Systems	(4.4.1) MWLD	#1	#2	#3	#4	LCA	CIA	(4.4.2.3) CVKI	(4.2.1) M16	(4.2.2) M60	M2	M85	(4.2.3) DRAGON	(4.2.4) VIPER	(4.3.3) TOW	(4.3.1) 105 mm	(4.3.2) 152 mm	(4.1.10) Contr. Gun Xmtr. Assy.	(4.6) ATWESS Firing Assy.
M16A1 Rifle (4.1.1)	1								1										
M60 Machine Gun (4.1.2)	1									1									
M60A1/A3 Tank (4.1.3)	3			2	1	1		1				1				1			
M551 AARV (4.1.5)	3			2	1	1		1			1						1		
M113 APC (4.1.6)		2	2				1	1			1								
TOW (4.1.7)	2														1				1
DRAGON (4.1.8)	1												1						1
VIPER (4.1.9)														1					1
CONTROLLER GUN (4.1.10)																		1	
SMALL ARMS ALIGNMENT FIXTURE																			
VEHICLE SYSTEMS TEST SET																			

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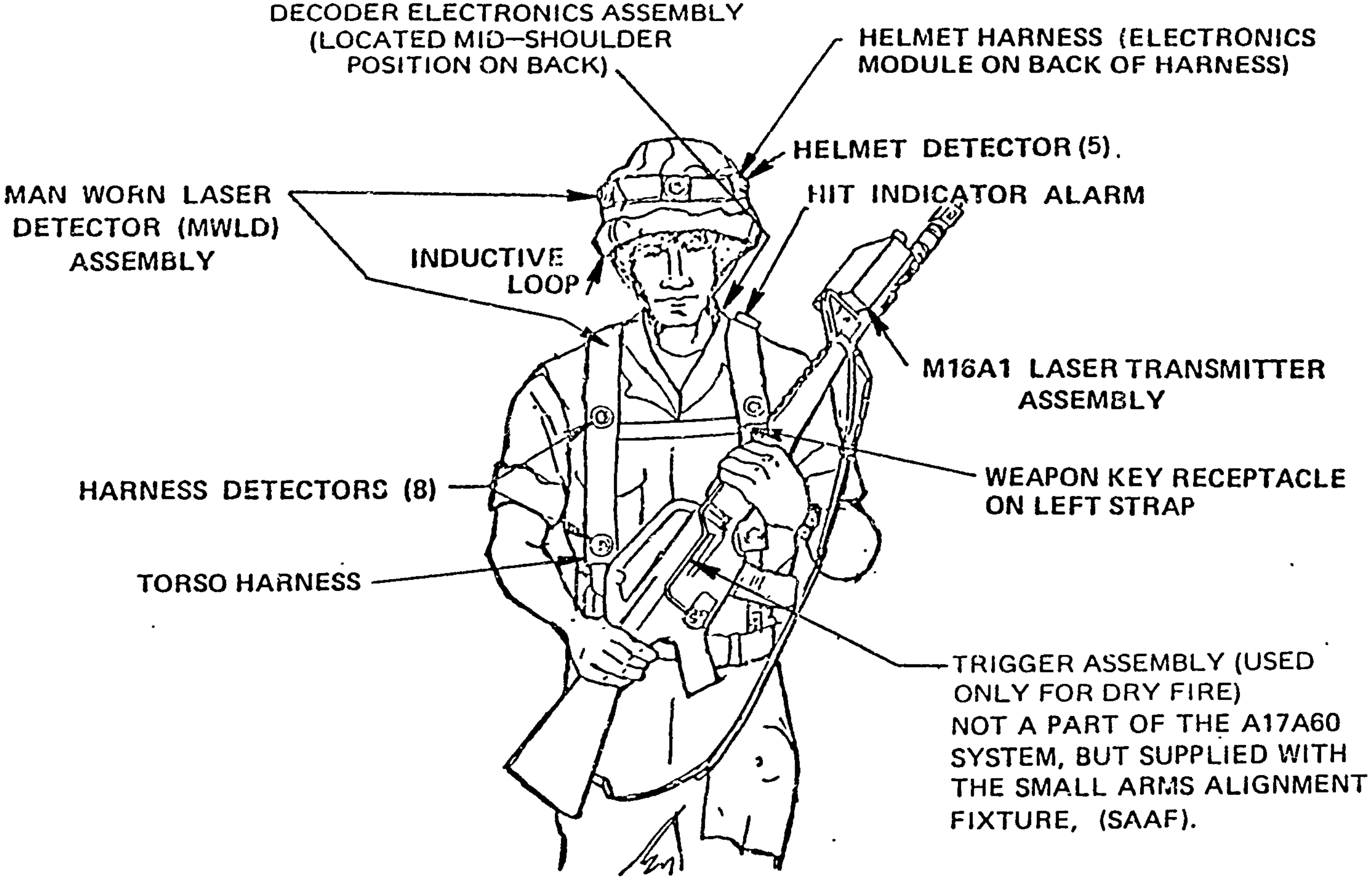

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Figure 4-1. M16A1 Rifle System (A17A60)

- ☐ Inserting the yellow weapon key into the MWLD receptacle shuts off the alarm. In so doing, the weapon is deactivated. Reinsertion of the weapon key into the transmitter reactivates the laser transmitter, but removal of the key from the MWLD causes the alarm to sound. Only the controller key will reset the MWLD and shut down the alarm.

- ☐ Blank Fire Mode - The laser transmitter is triggered by the firing of blanks. Laser rounds equal blanks issued.

- ☐ Dry Fire Mode - Different only in that the laser transmitter is provided with a basic store of "ammunition." When its basic store is expended through firing, the transmitter is deactivated and must be reset and resupplied with a controller key. Closure of the trigger switch with a controller key inserted supplies the weapon with 210 rounds of ammunition. The transmitter has a single burst limit of 30 rounds when used in the "automatic" mode.

4.1.2 SIMULATOR SYSTEM, FIRING, LASER: M61 FOR M60 MACHINE GUN (MILES DEVICE A17A61)

System Description

The A17A61 M60 Machine Gun system, shown in figure 4-2, consists of one each of the following items:

a. Laser Transmitter, M60 Machine Gun (7.62 mm)

b. Weapon Key (yellow)

TheM60 gunner also wears a Man-Worn Laser Detector (MWLD) which is not part of the M60 Machine Gun System. The gunner receives the MWLD from an M16A1 Rifle System which he was previously issued. *

Tactical Scenario

- ☐ A crew of one is assumed - the M60 gunner.

- ☐ Kill the M60 gunner - his hit indicator alarm can be shut down by inserting his or another yellow weapon key in the MWLD receptacle.

- ☐ The squad leader can sacrifice rifles to save the machine gun by using the weapon key from any rifle to deactivate the MWLD alarm.

- ☐ Blank Fire/Dry Fire functions are same as M16A1 except for the basic store of ammunition. In the Dry Fire Mode, the M60 basic store is 600 rounds, and the transmitter has a burst limit of 100 rounds. No Trigger Cable Assembly is provided with the M60. For dry fire operation, a cable assembly available from the Controller must be used.

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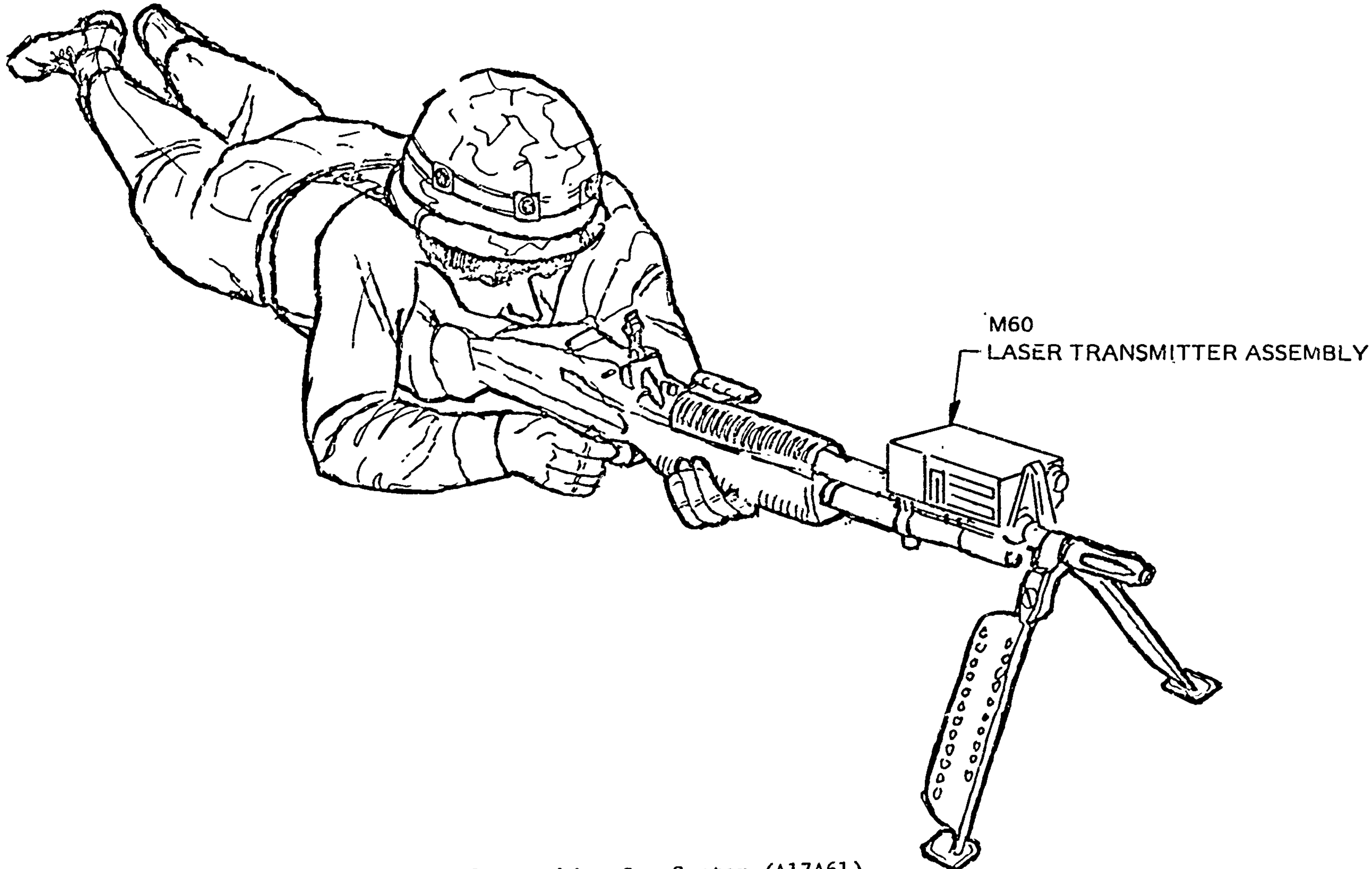


Figure 4-2. Machine Gun System (A17A61)

4.1.3 SIMULATOR SYSTEM, FIRING, LASER: M65 FOR M60A1/A3 TANK (MILES DEVICE A17B8)

System Description

The A17B8 M60A1/A3 Tank system, shown in figure 4-3, consists of one each of the following items except where otherwise noted:

a. 105mm Transmitter assembly
   - Laser Transmitter, 105 mm Tank Gun
   - Laser Transmitter, Coax Machine Gun, 7.62 mm
   - Extractor Stop Assembly
   - Retainer Assembly

b. Laser Transmitter, M85 Machine Gun Cupola Mounted, 50 caliber
   - Weapon Key (orange)

c. 1 each M60A1/A3 Belt Set
   - Detector Belt Assembly Segment No. 3 (2 each)
   - Detector Belt Assembly Segment No. 4

d. Loader Control Assembly (LCA)

e. Kill Indicator, Combat Vehicle (CVKI)

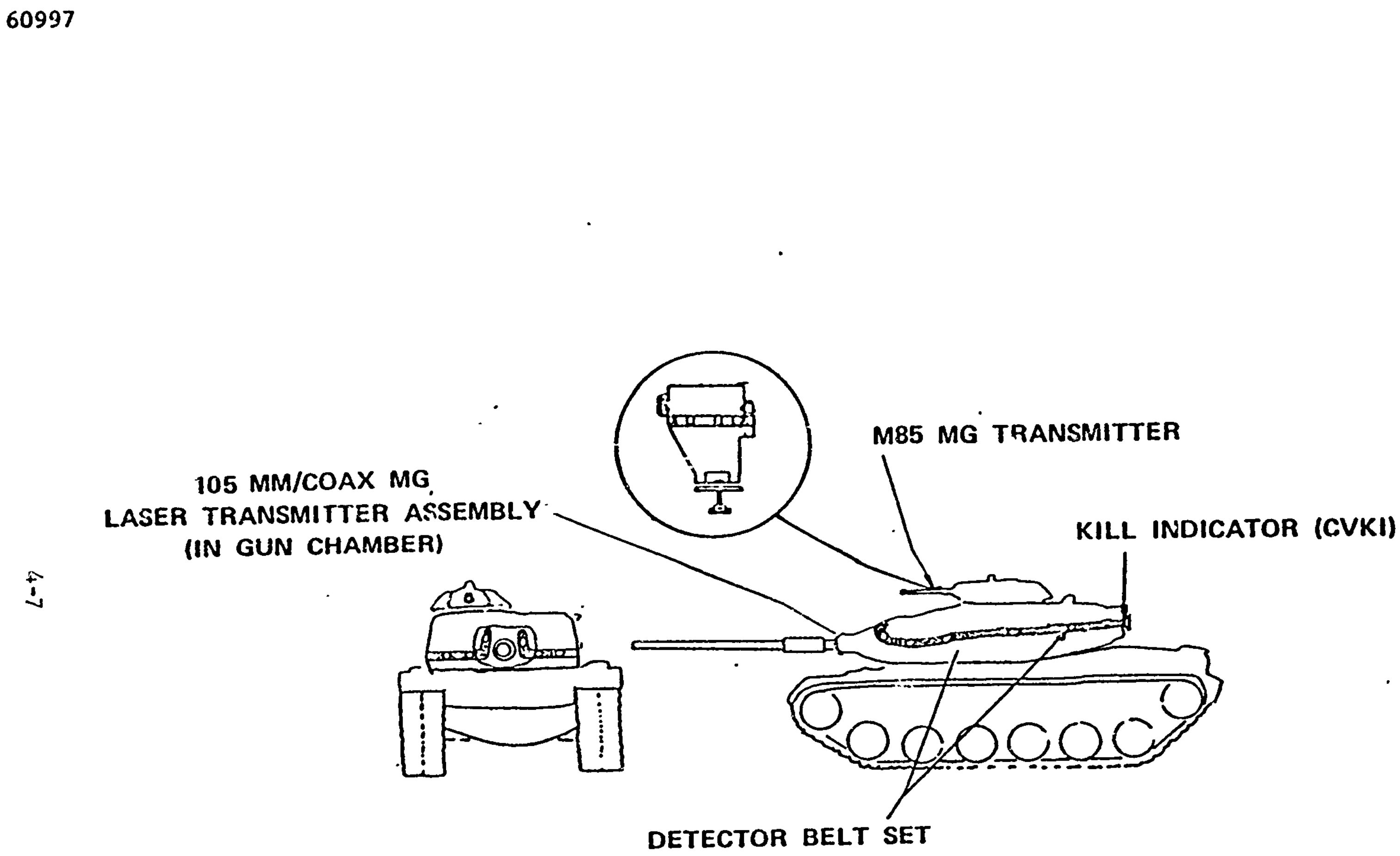
f. Battery Box

g. Adapter Kit, M60A1/A3 Tank
   - Trigger Cable Assembly
   - Breech Cable Assembly
   - CVKI Cable Assembly
   - Coax Adapter Microphone Assembly
   - Detector Belt Wedge Assembly (10 each)
   - Console Mounting Adapter Assembly
   - Weapon Keys (yellow) (3 each)
   - Ground Strap

h. Laser Detectors, Man Worn (3 each) - The tank commander, gunner, and loader wear MWLDs.

Tactical Scenario

☐ One Weapon Key (orange) in Cupola Machine Gun



NOTE:
THE TANK COMMANDER, GUNNER,
AND LOADER WEAR MWLD
THE LOADERS CONTROL ASSEMBLY (LCA)
IS LOCATED INSIDE TURRET.

Figure 4-3. M60A1/A3 Tank System (A17B8)

- ☐ Tank kill - all weapons automatically disabled except cupola machine gun. Intercom alarm and CVKI activated.

- ☐ Intercom alarm shuts off when commander removes weapon key from cupola machine gun and inserts it in Loaders Control Assembly. This disables cupola machine gun and shuts down intercom alarm.

- ☐ Three MWLD (yellow) weapon keys are provided - one each for the tank commander, gunner, and loader to shut down their MWLD hit indicator alarms when they are "killed." *

4.1.4 SIMULATOR SYSTEM. FIRING. LASER: M66 FOR M60A2 TANK (MILES DEVICE A17B9)

MILES system design was initiated for the M60A2 tank. however. the system was not procured. A system description of the proposed MILES equipment and an installation diagram are described in the following paragraphs.

System Description

The A17B9 M60A2 Tank System, shown in figure 4-4. consists of one each of the following items:

a. M60A2 Laser Transmitter Assembly
   - Laser Transmitter. 152 mm Main Gun
   - Laser Transmitter. Shillelagh Missile
   - Laser Transmitter. Coax Machine Gun, 7.62 mm

b. Laser Transmitter, M85 Machine Gun, 50 caliber
   - Weapon Key (orange)

c. 1 each M60A2 Belt Set
   - Detector Belt Assembly. Segment No. 3 (2 each)
   - Detector Belt Assembly, Segment No. 5

d. Loader Control Assembly (LCA)

e. Kill Indicator, Combat Vehicle (CVKI)

f. Battery Box

g. Adapter Kit, M60A2
   - Kill Indicator Cable Assembly
   - Breech Cable Assembly
     - Breech Interlock Plug Assembly

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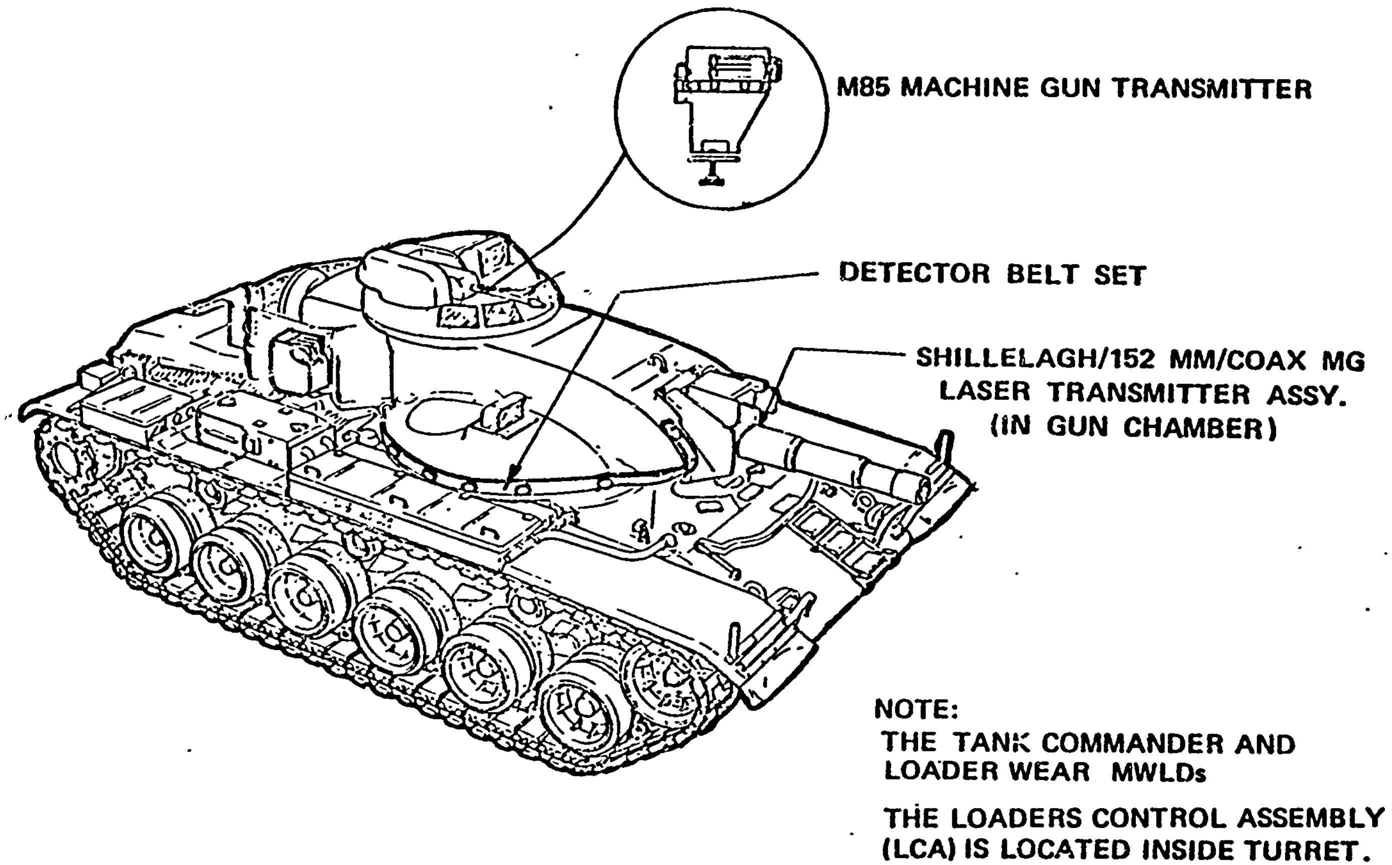

Figure 4-4. M60A2 Tank System (A17B9)

- Trigger Cable Assembly
- Coax Adapter Microphone Assembly
- Console Mounting Adapter Assembly
- Weapon Keys -yellow (3 each)
- Ground Strap

h. Laser Detectors, Man-Worn (3 each). The tank commander, gunner, and loader wear MWLDs.

Tactical Scenario

The tactical scenario is the same as that described for the M60A1 tank (refer to subsection 4.1.3).

4.1.5 SIMULATOR SYSTEM, FIRING, LASER: M67 FOR M551 VEHICLE (MILES DEVICE A17B10)

System Description

The A17B10 M551 AARV system, shown in figure 4-5, consists of one each of the following items except where otherwise noted:

a. M551 Laser Transmitter Assembly
   - Laser Transmitter, 152 mm Main Gun
   - Laser Transmitter , Shillelagh Missile
   - Laser Transmitter Coax Machine Gun, 7.62 mm

b. Laser Transmitter M2 Machine Gun, 50 caliber
   - Weapon Key (orange)

c. M551 Belt Set
   - Detector Belt Assembly, Segment No. 3 (2 each)
   - Detector Belt Assembly, Segment No. 4 (1 each) *

d. Loader Control Assembly (LCA)

e. Kill Indicator, Combat Vehicle (CVKI)

f. Laser Detector, Man-Worn (3 each). The tank commander, gunner, and loader wear MWLDs

g. Battery Box

h. M551 Adapter Kit
   - Trigger Cable Assembly

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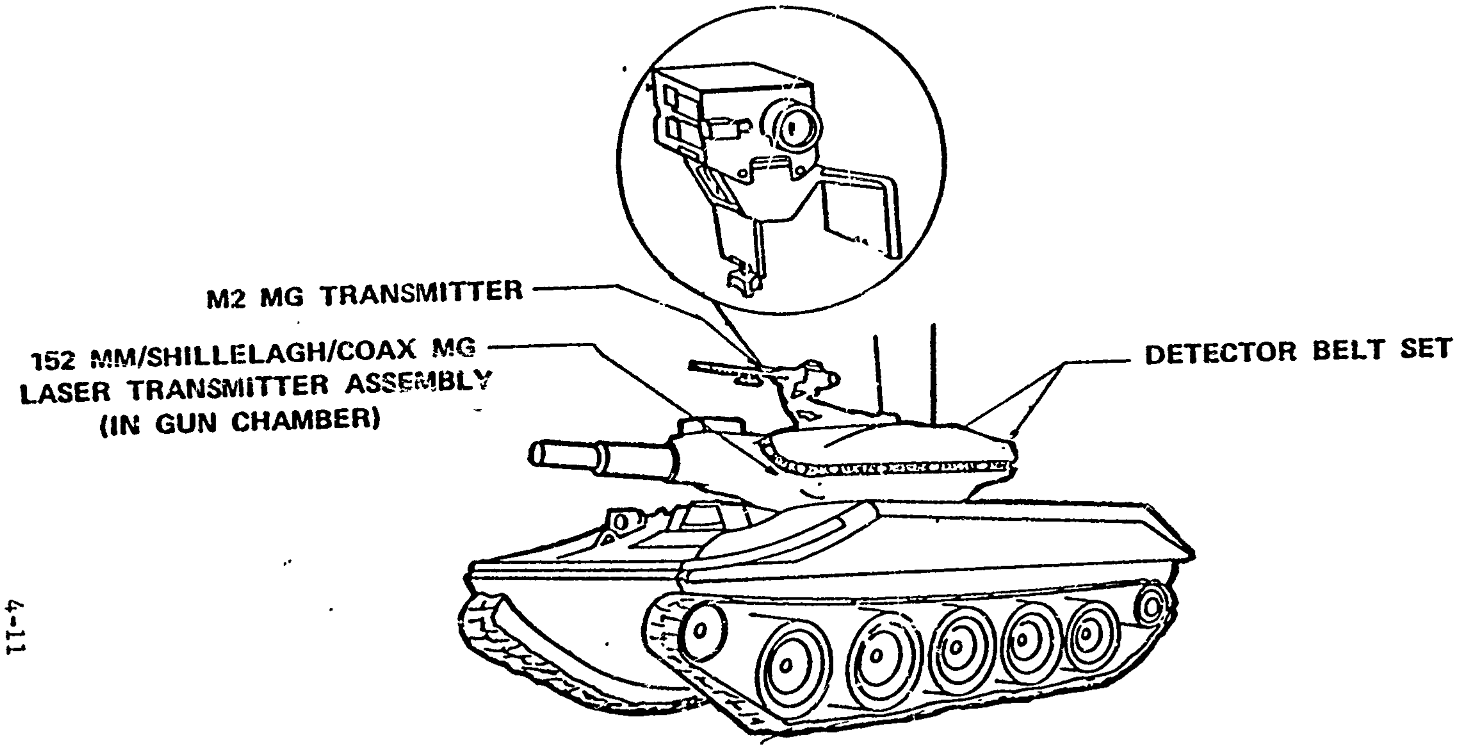

NOTE: THE TANK COMMANDER, GUNNER, AND LOADER WEAR MWLD

THE LOADERS CONTROL ASSEMBLY (LCA) IS LOCATED INSIDE TURRET.

Figure 4-5. M551 AARV System (A17B10)

- Breech Cable Assembly
- Breech Interlock Plug Assembly
- Kill Indicator Cable Assembly
- Coax Adapter Microphone Assembly
- Detector Belt Wedge Assemblies (14 each)
- Console Mounting Adapter
- Ground Strap
- Weapon Keys - yellow (3 each)

Tactical Scenario

The tactical scenario is the same as that described for the M60A1 Tank (refer to subsection 4.1.3).

4.1.6 SIMULATOR SYSTEM, FIRING, LASER: M63 FOR M113 APC (MILES DEVICE A17A62)

System Description

The A17A62 M113 Armored Personnel Carrier system, shown in figure 4-6, consists of one each of the following items except where otherwise noted:

a. Laser Transmitter, M2 Machine Gun, 50 caliber
    - Weapon Key (orange)

b. M113 APC Belt Set, Laser Detector
    - Detector Belt Assembly, Segment No. 1 (2 each)
    - Detector Belt Assembly, Segment No. 2 (2 each)

c. Brush Guards (12 segments)

d. Control Indicator Assembly (CIA)

e. Kill Indicator, Combat Vehicle (CVKI)

f. Battery Box

g. Adapter Kit, M113 APC
    - Kill Indicator Cable Assembly
    - Control Indicator Mounting Adapter (Left and Right)
    - Control Indicator Adapter Plate and Mount (TOW equipped vehicles)

h. Laser Detector, Man Worn

The crew consists of a driver. The M2 weapon is manned by a squad member.

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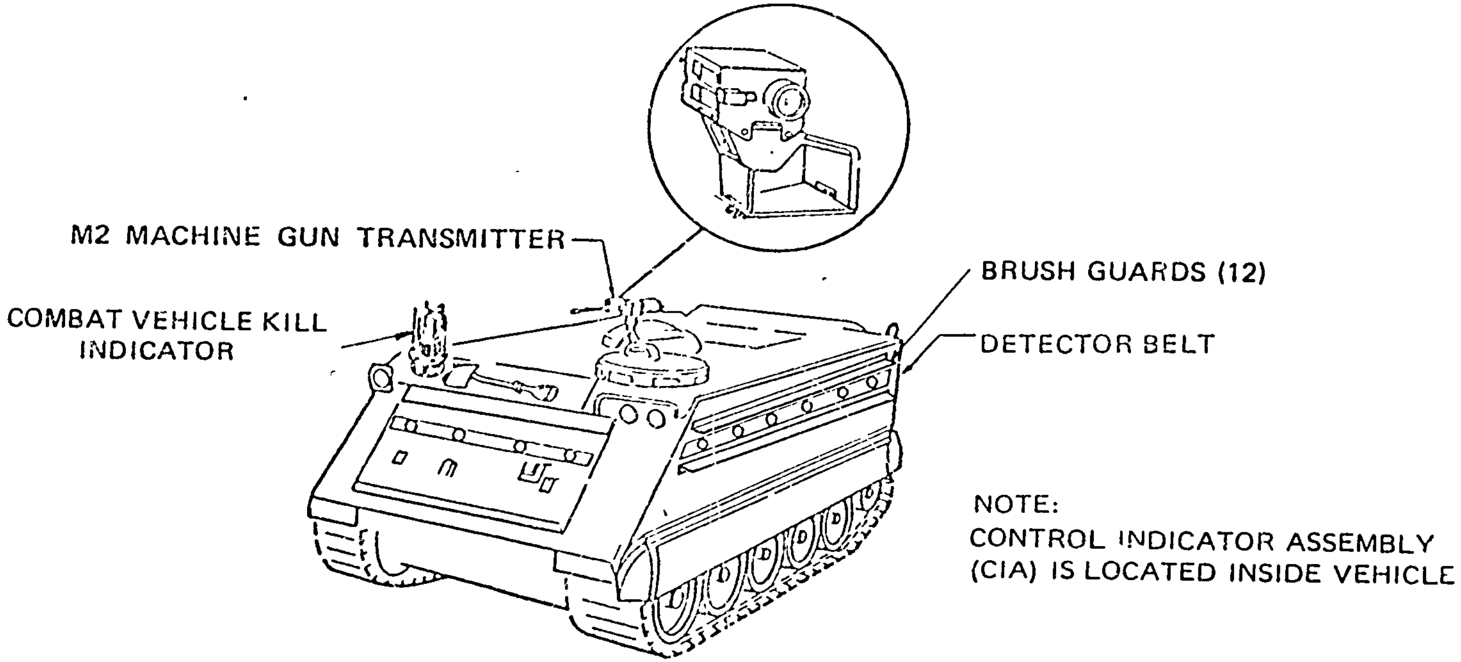

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Figure 4-6. M113 APC/M2 System (A17A62)

Tactical Scenario

A crew of one (the driver) is assumed; all other personnel are passengers. A squad member mans the M2 50 caliber machine gun. When the vehicle is killed, the intercom audio alarm and CVKI strobe light are activated. The M2 orange weapon key is used to shut off the intercom audio alarm. All personnel aboard are "dead" by controller decision if the vehicle is killed. The CVKI strobe light continues flashing until reset by the Controller.

4.1.7 SIMULATOR SYSTEM, FIRING, LASER: FOR TOW

System Description

The TOW weapon system, shown in figure 4-7, consists of one each of the following items:

a. Laser Transmitter, TOW Missile

b. TOW/ATWESS Tube Assembly

c. Missile Guidance Set Simulator *

Tactical Scenario

A crew of five infantrymen with M16A1 rifle systems is assumed. The TOW system has laser detectors permanently installed on the tracker head.

Situation - The Tow weapon is "killed" by a tank or antitank weapon.

a. Audio indicator (located in the MGS Simulator) is activated. *

b. The TOW is automatically disabled.

c. No TOW weapon key.

d. Audio alarm is shut down by the Controller resetting the system with his key. Crew may shut off alarm by unplugging the coil cord from the MGS simulator.

4.1.8 SIMULATOR SYSTEM, FIRING, LASER: FOR DRAGON MISSILE (MILES DEVICE A17C5)

System Description

The A17C5 DRAGON Missile system, shown in figure 4-8, consists of one each of the following items:

a. Laser Transmitter, DRAGON Missile

- Weapon Key (yellow)

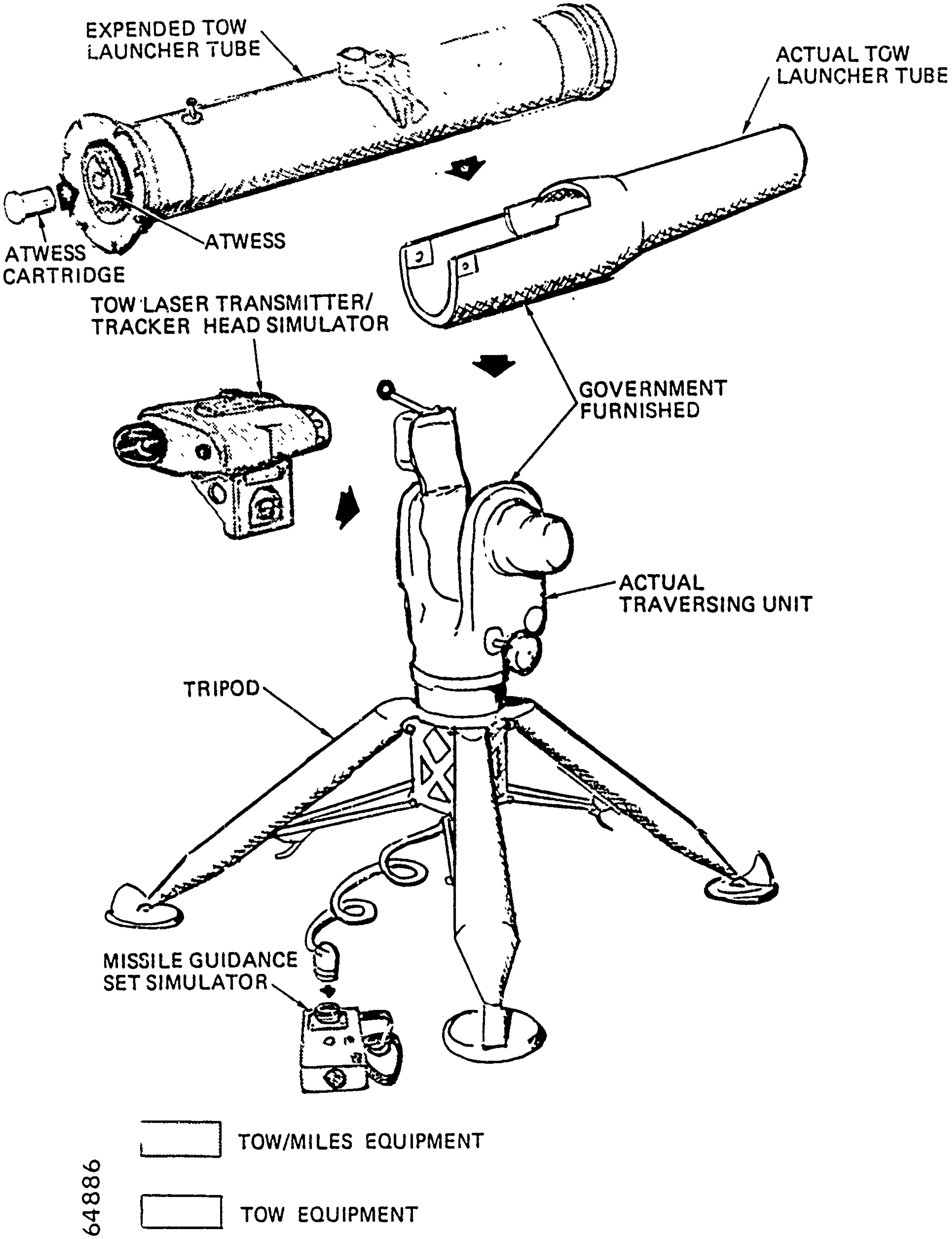

Figure 4-7. TOW Weapon System

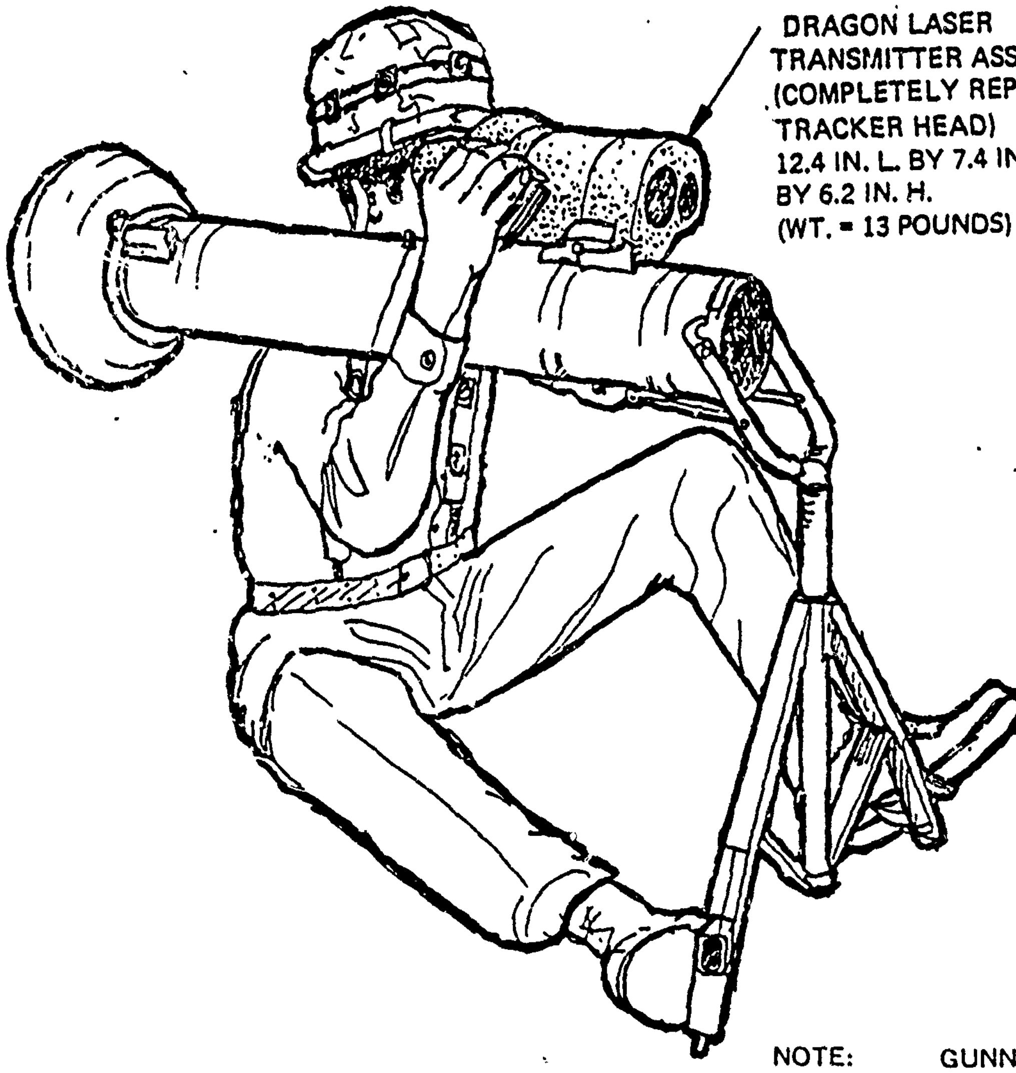

Figure 4-8. Dragon Missile System (A17C5)

b. Laser Detector, Man-Worn (MWLD)

c. Tube Assembly, Simulator, Antitank Missile Fire

d. ATWESS Firing Device Assembly

<u>Tactical Scenario</u>

A crew of one is assumed, the DRAGON gunner. The scenario is the same as for the M60 machine gun (refer to subsection 4.1.2) except for basic store of ammunition. The DRAGON has a basic store of 4 rounds and a firing rate of 4 rounds per minute.

4.1.9 SIMULATOR SYSTEM, FIRING, LASER: M68 FOR LAW/VIPER ROCKET (MILES DEVICE A17C7)

<u>System Description</u>

The A17C7 VIPER Missile system, shown in figure 4-9, consists of one each of the following items:

a. Laser Transmitter, VIPER Missile

b. ATWESS Firing Device Assembly

The VIPER gunner is an infantryman who is already equipped with an M16A1 rifle system.

<u>Tactical Scenario</u>

- ☐ VIPER gunner also carries rifle (M16A1) with weapon key.
- ☐ Kill VIPER gunner - he removes the yellow weapon key from his M16 rifle, thus disabling it, and shuts down the MWLD hit indicator alarm by inserting the weapon key from the M16 Laser Transmitter into the weapon key receptacle on the MWLD Torso Harness.
- ☐ No VIPER weapon key.
- ☐ VIPER simulator remains active and can be fired by other infantrymen until the basic store of four rounds is expended. Its firing rate is 6 rounds per minute.

4.1.10 CONTROLLER GUN, SIMULATOR SYSTEM, LASER (MILES DEVICE A17A63)

The controller gun is a lightweight handheld device capable of interrogating both the man-worn and vehicle-mounted laser detection systems in the field to determine if the systems are operational. The controller has the capability of resetting both systems when a kill has been effected and of restoring basic ammunition loads. This is accomplished with the green controller key included as a part of the system.

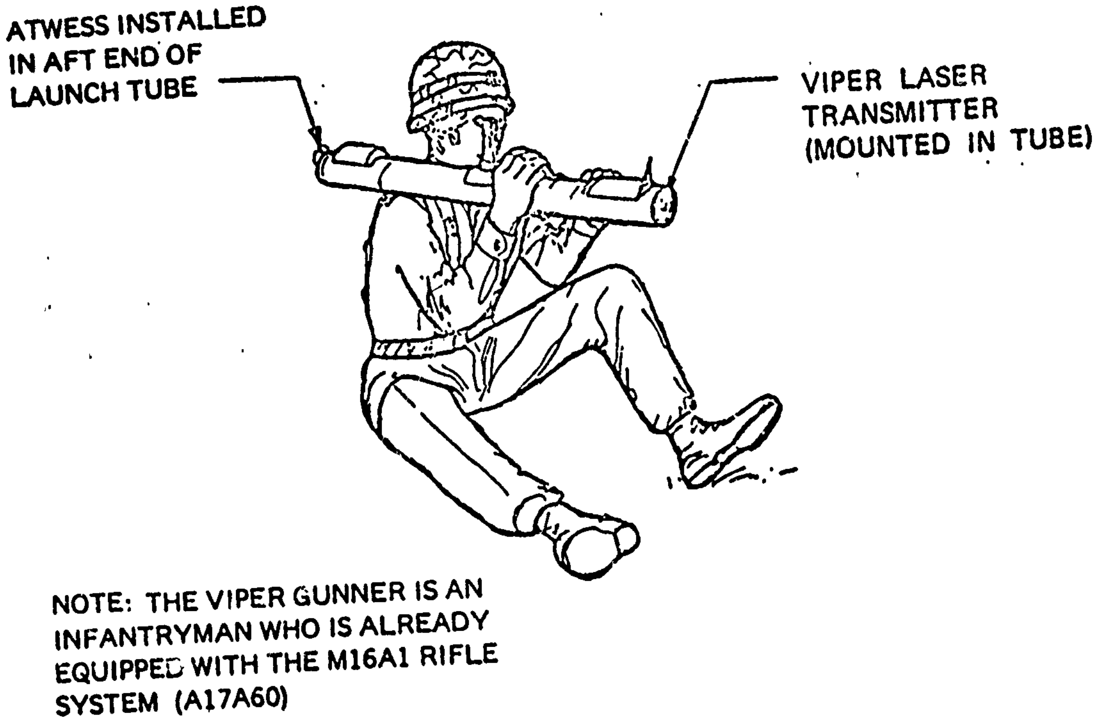

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Figure 4-9. Viper System (A17C7)

Figure 4-10 depicts an earlier version of the controller gun. The sighting is done with iron sights. The sights are factory aligned to the laser beams and there is thus no need for field alignment. The controller key is attached to the controller gun lanyard. The difference between this configuration and the latest is that the mode selector switch which was used to select either a kill or near miss signal has been replaced with two pushbutton switches. In the new configuration, if the trigger alone is depressed, the transmitter sends out a near miss signal. If one of the pushbuttons and the trigger are depressed together, the transmitter sends out a man kill signal. The third signal the controller gun transmits is a vehicle kill signal. This is generated by depressing the second pushbutton and the trigger together.

This change in configuration was prompted by field testing which indicated it was desirable to be able to kill infantry who were located close to vehicles without killing the vehicles themselves. Also, accidental selection of the universal hit code resulted in unintentional killing of vehicles or personnel when it was only desired to inflict a near miss. The need to simultaneously activate two buttons to transmit kill signals will prevent this accidental killing. Figure 4-11 is an outline drawing of the new configuration.

The controller gun has an interrogation range greater than 500 meters, which field testing indicates is ample. The transmitter will fire continuously as long as the trigger is depressed. There is no ammunition limit for the controller gun.

Controller Reset Key

The controller key is readily distinguished by its green color. The controller key fits in the same receptacle as the weapon keys. When inserted, the controller key restores the basic ammunition load of the weapon simulator. The laser transmitter will then operate normally once the weapon key is reinserted.

The controller key, when inserted in the control console weapon key receptacle of a "killed" vehicle or in the MWLD weapon key receptacle, will cause the system to reset to the unkilled state.

Both the weapon key and controller reset key, as well as their mating guides, are configured to prevent incorrect insertion and to preclude the key from falling out of the receptacle during operation. Further detail on the use of the weapon and controller keys is given in subsection 4.9.

4.1.11 ASSEMBLY INTERRELATIONSHIPS

The MILES systems are comprised of numerous assemblies which exhibit considerable commonality. These assemblies are discussed in detail in subsections 4.2 through 4.6. Sections 4.7 through 4.9 treat the more important functions and operation of the assemblies that are common to all.

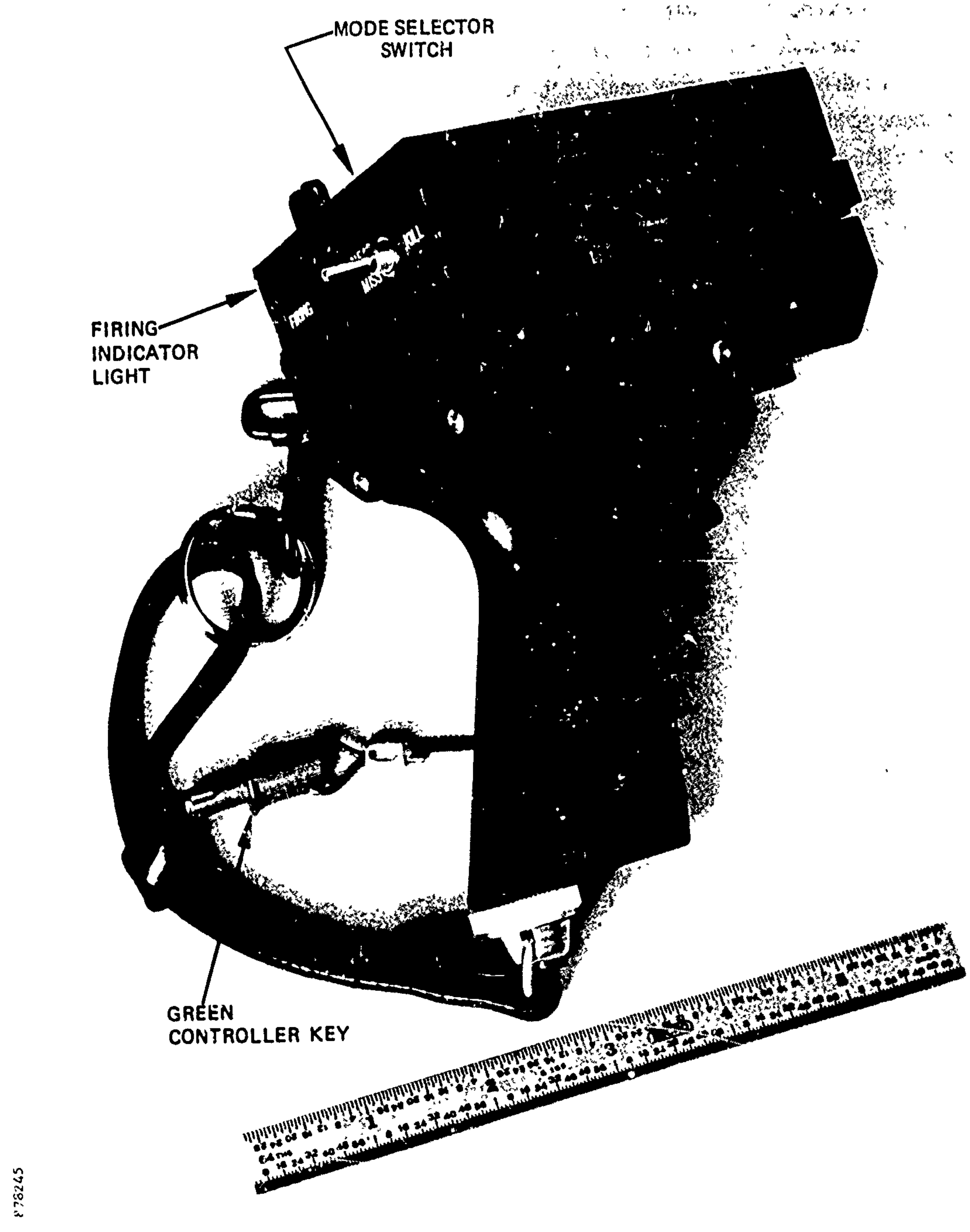

Figure 4-10. Controller Gun

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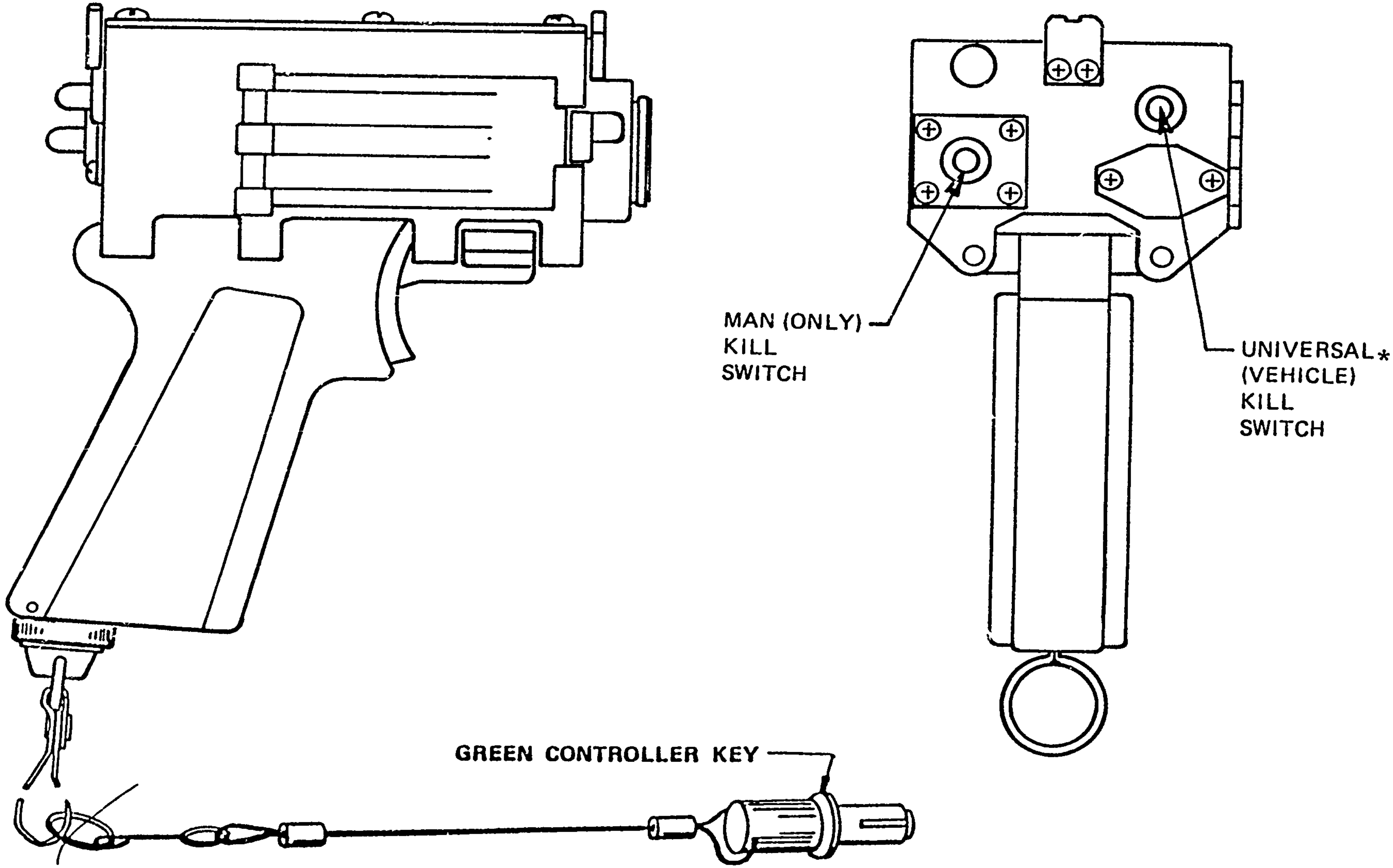

Figure 4-11. Controller Gun Outline Drawing

Figure 4-12 is included as a guide to show how the various MILES assemblies interrelate to each other in the forming of MILES systems. The reader should have a good understanding of this chart before proceeding with the detailed discussions in the subsections that follow.

4.2 INDEPENDENT LASER TRANSMITTERS

The independent laser transmitters are so called because they are self-contained including a 9 volt battery for power and require no other companion units for operation. Figure 4-13 is a block diagram typical of most of the independent laser transmitters. All functions from weapon triggering to laser message transmission are completed within the assembly. The TOW, although an independent transmitter, differs slightly and its block diagram is shown in figure 4-14.

4.2.1 M16A1 LASER TRANSMITTER ASSEMBLY

The M16 transmitter is typical of most of the MILES transmitters and is therefore discussed in detail in this subsection. Other independent laser transmitters are discussed in following subsections only insofar as they differ from the M16.

4.2.1.1 General Description

The M16 rifle simulator consists of a small, lightweight laser transmitter that attaches to the barrel of the M16 rifle forward of the front sight. The battery-powered transmitter is operated by use of a trigger switch and cable in the dry fire (no blanks) mode, or remotely by use of a microphone which fires the laser each time a blank cartridge is fired in the weapon.

The M16 transmitter is contained in a single housing and cover. A hinged door provides access to the single 9 volt battery. A receptacle located on the rear of the transmitter housing accepts the weapon key which is used to enable the unit and to disable the unit after its operator has been "killed" by an opponent.

All electronic components required for providing signals to the laser driver and laser tube assembly are contained on three printed wiring board assemblies.

4.2.1.2 External Configuration

Figure 4-15 shows the M16 laser transmitter rear, side, and top views, and figure 4-16 is a photograph of the rear. Visible in these views are:

a. Side View

The hinged door to the battery compartment. An over-center latch when released allows the door to open for installation or removal of batteries.

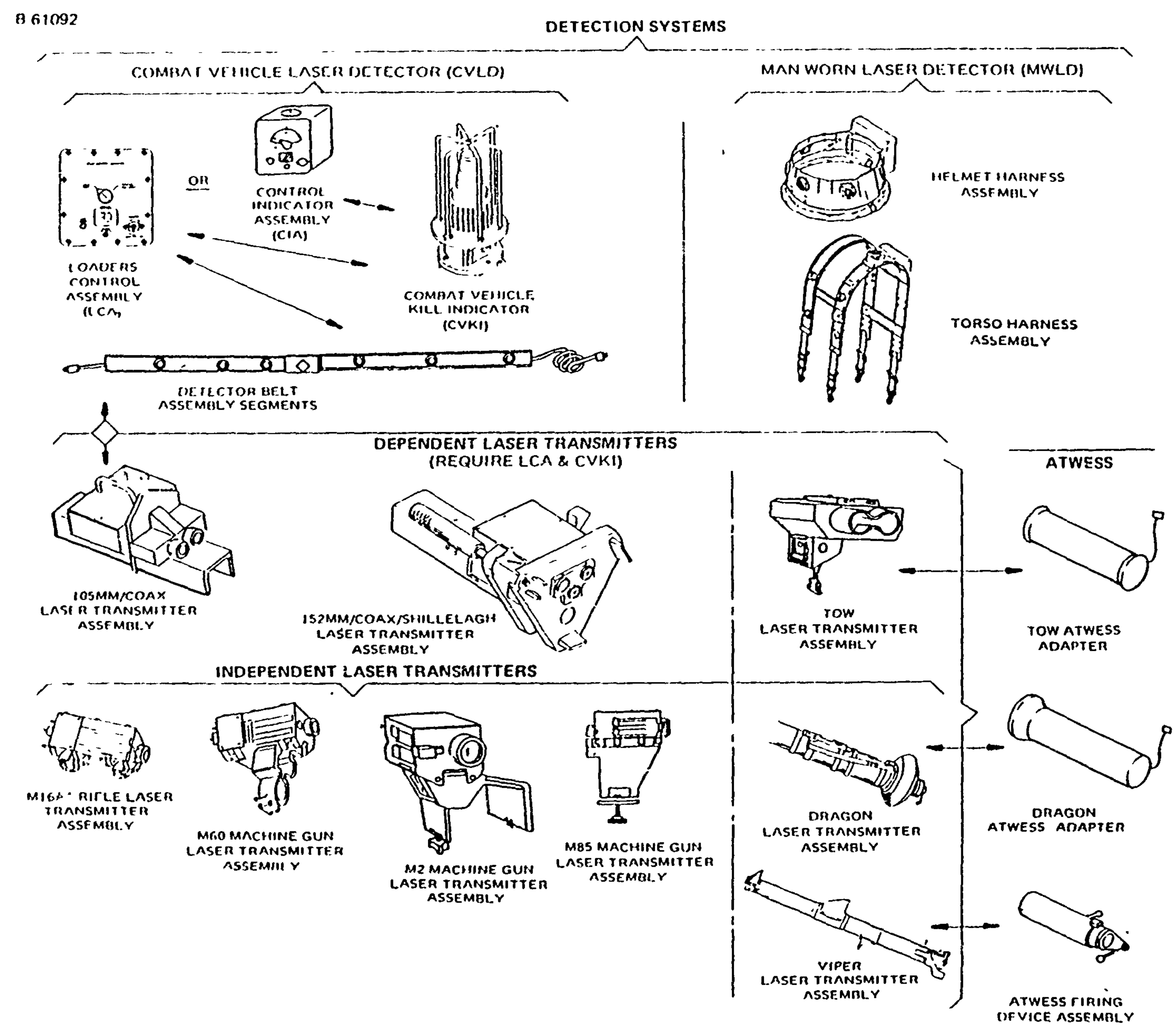

Figure 4-12. MILES Major Assemblies

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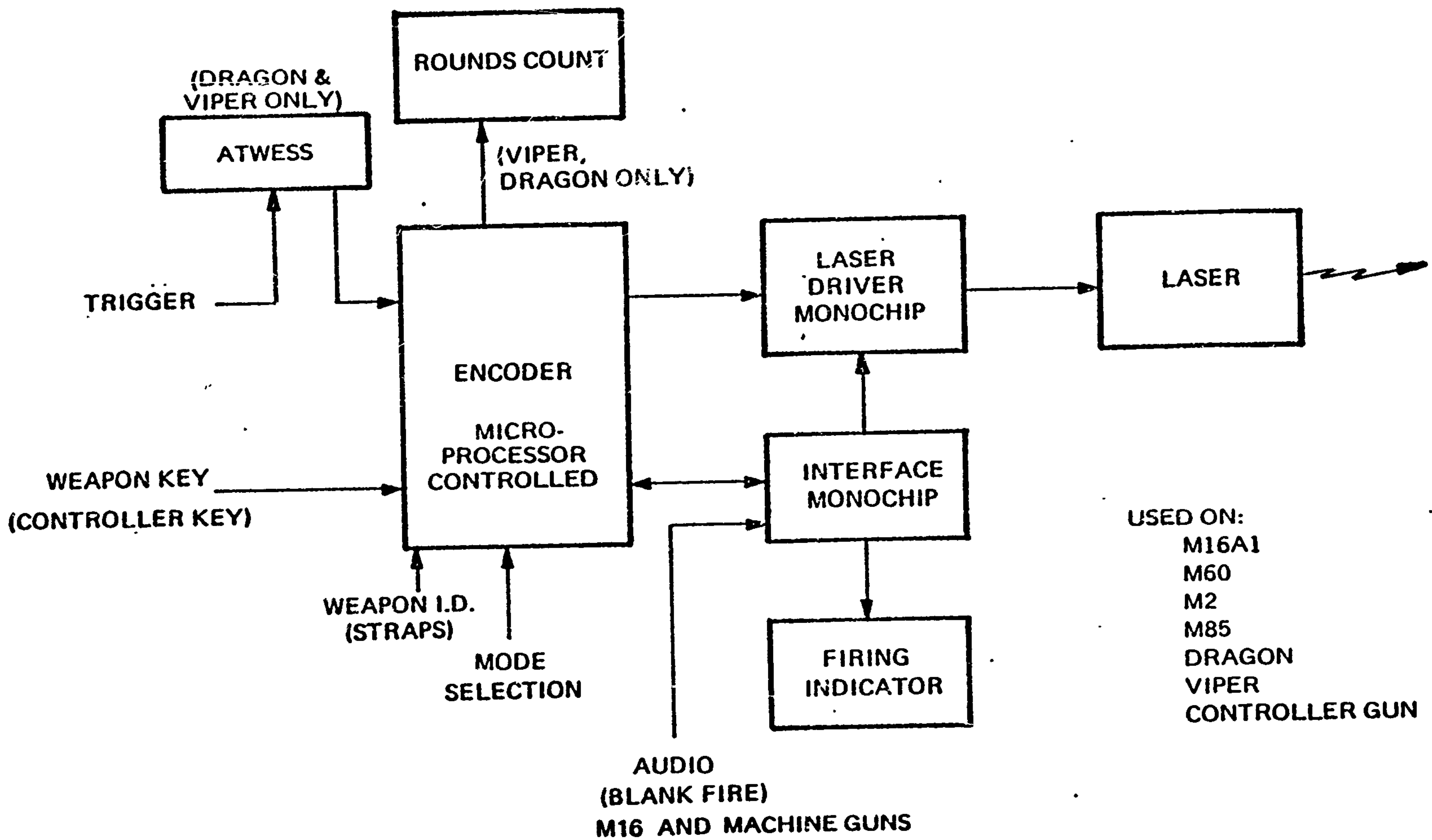

Figure 4-13. Independent Laser Transmitter Functional Block Diagram

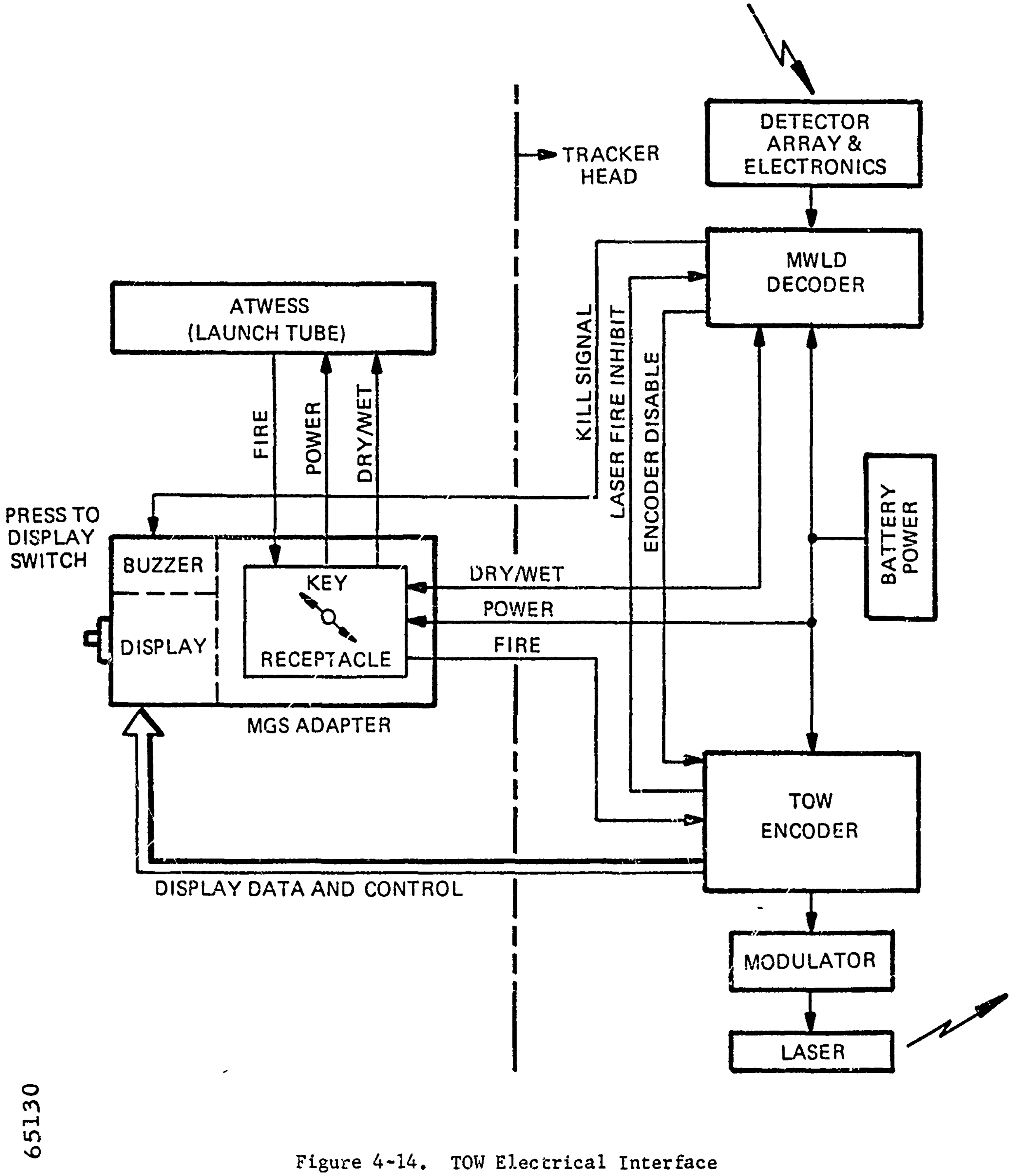

Figure 4-14. TOW Electrical Interface

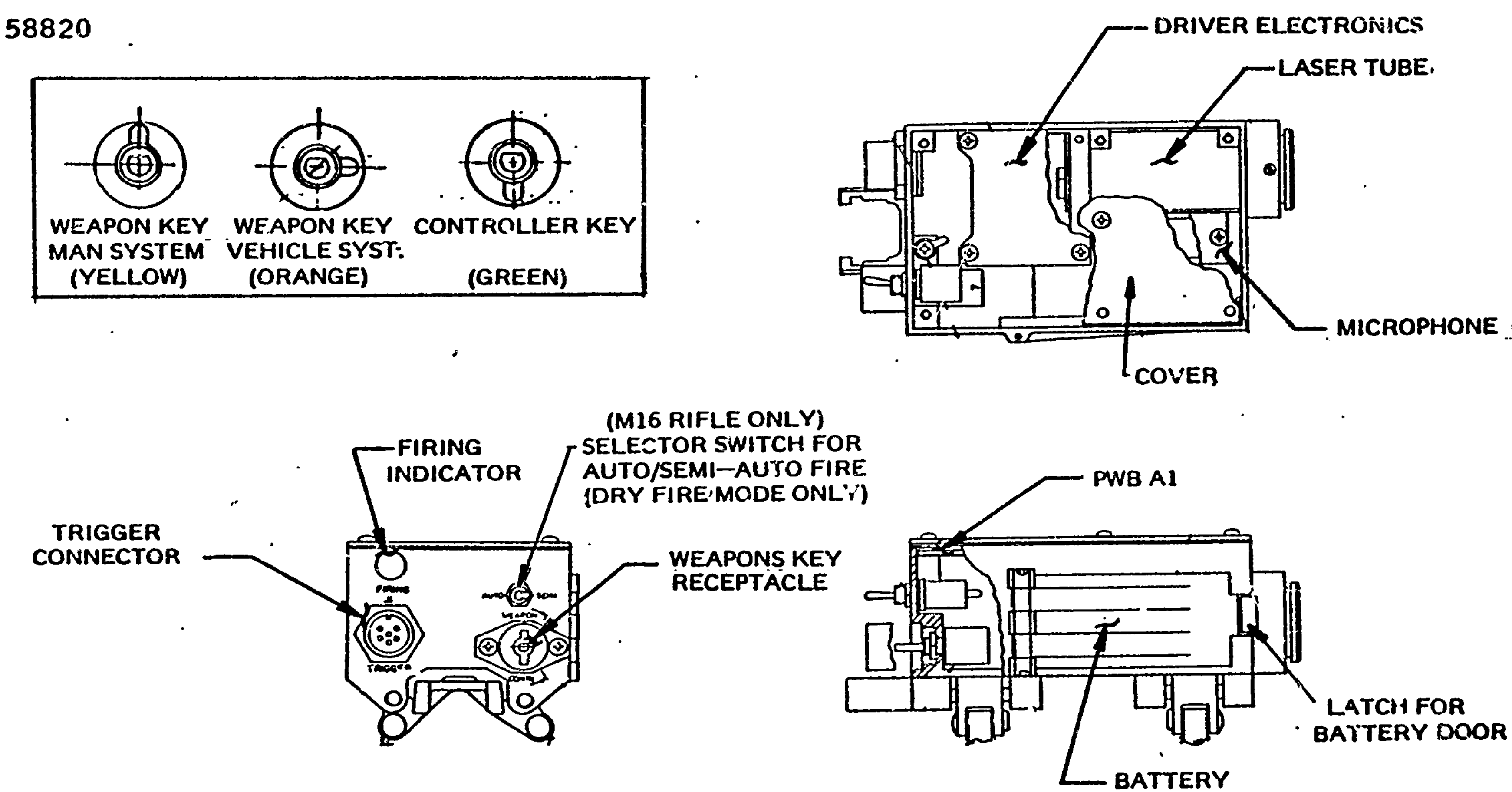

Figure 4-15. M16A1 Laser Transmitter and Weapon Key Configurations

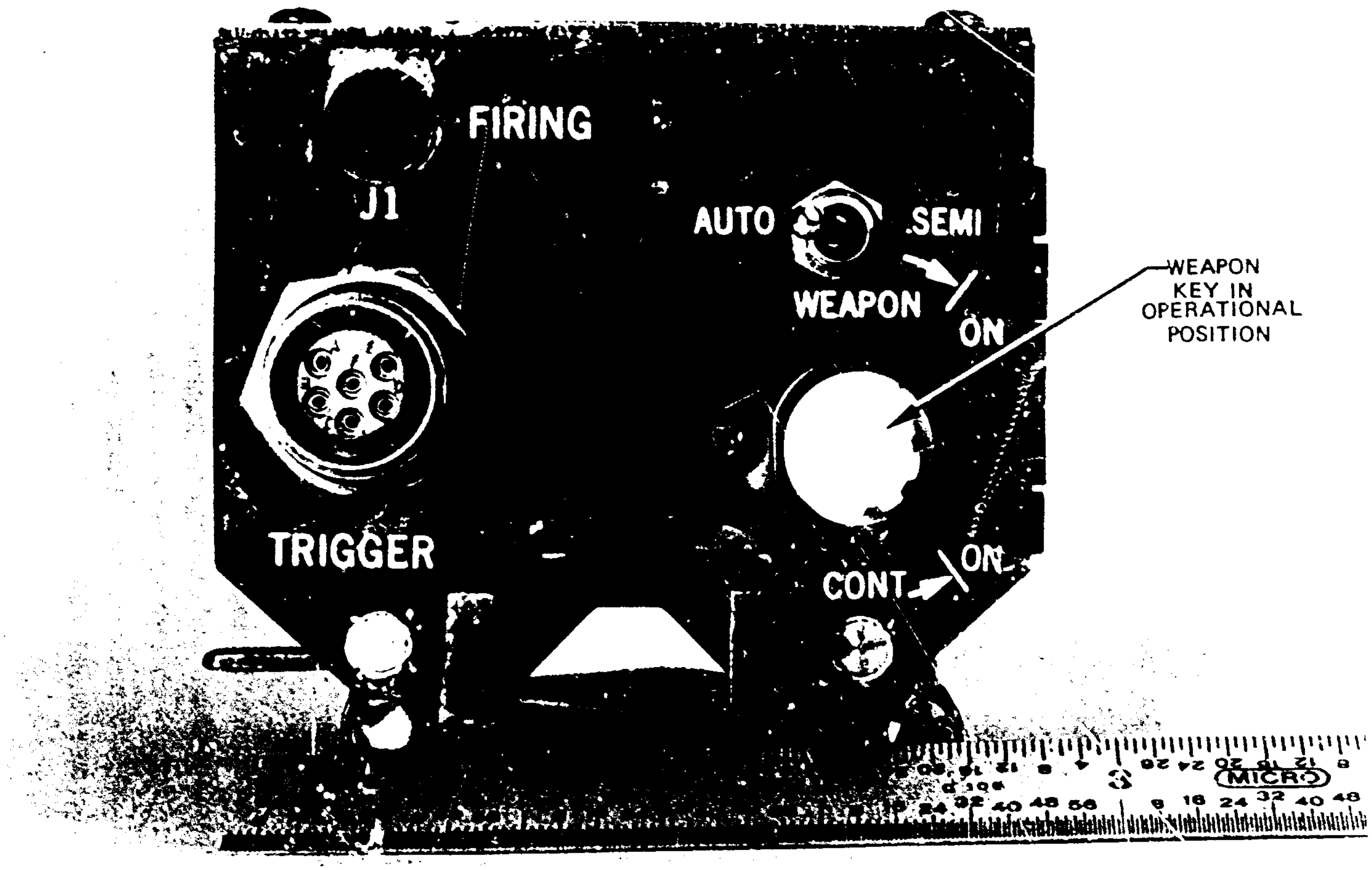

Figure 4-16. M16A1 Transmitter, Rear View

b. Rear View (see figure 4-16)

- Firing Indicator - a red LED flashes each time the laser fires.

- Trigger Connector - a six pin connector which mates to the trigger assembly for:

  (1) Dry fire operation

  (2) External power

  (3) Boresight code

- Selector Switch - A toggle switch used to select either automatic or semiautomatic firing when in the dry fire mode. This switch is used only on the M16A1 rifle transmitter.

- Weapon Key Receptacle - this receptacle mates with the weapon key and with the controller key. Functions of these keys are explained in detail in subsection 4.9. The weapon key must be in the receptacle and turned to the on position for the laser transmitter to operate.

c. Top View

- Laser Tube - the housing which contains the laser diode, optics, and a portion of the electronic circuitry. This tube is purged, sealed, and filled with dry nitrogen.

- Cover - this top cover when removed allows access to the transmitter electronics contained on three printed wiring boards.

The insert on figure 4-15 shows the keying arrangement of the tabs on the three different weapon/controller keys used in the MILES system. The yellow weapon key is used with the M16A1 rifle and other man-carried weapons.

4.2.1.3 Construction

The general construction and assembly of the M16 transmitter is shown in figure 4-17. This exploded view shows the relationship of all the transmitter component parts or replaceable assemblies. With the exception of the toggle switch (used only on the M16A1 transmitter) this is the same construction used on the M60, M2, and M85 machine gun laser transmitters. Minor differences in the electronic assemblies or laser tube assembly differentiate between the laser transmitter assemblies for these weapons.

The basic materials of construction are aluminum for the metal parts and copper clad fiberglass for the printed wiring boards. Corrosion resistant steel is used where added strength is required - door hinge pins, etc. The housing, battery door, and door latches are castings, and the housing cover is a stamped

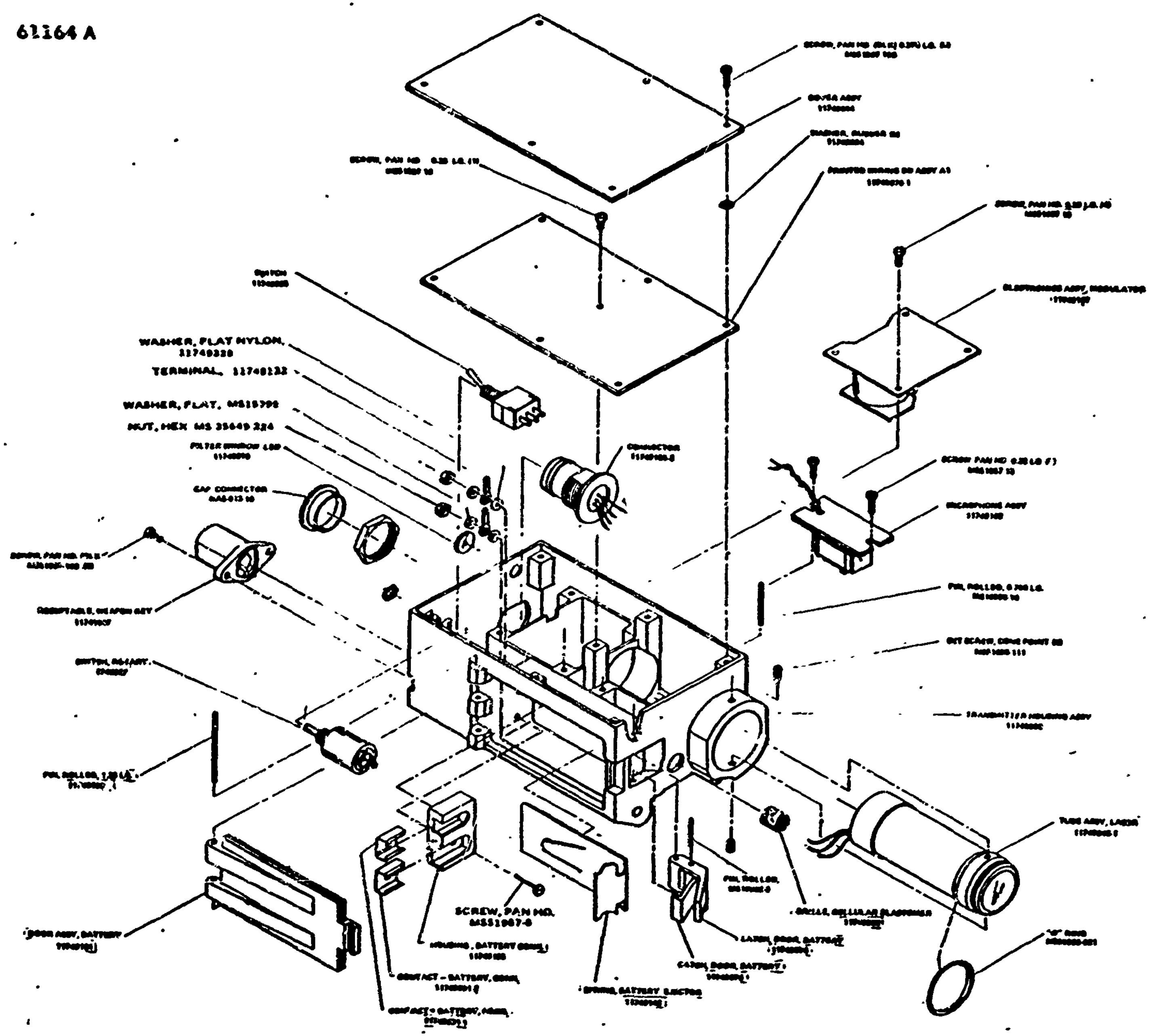

Figure 4-17. M16 Transmitter Construction

aluminum plate. The laser tube housing is a machined aluminum tube. An aluminum retaining ring positions and secures the glass optical lens.

4.2.1.4 Weapon Interface Attachment

The primary difference between the various small arms laser transmitters is the method of attachment to the weapon interface.

The M16A1 laser transmitter weapon attachment adapter is shown in figures 4-18 and 4-19. This adapter is permanently attached to the laser transmitter during manufacturing and the laser tube mounting hole is machined in line with the V-grooves on the attachment. These V-grooves are used to interface the weapon barrel. Thus, the laser tube is accurately aligned with the weapon barrel as a function of the manufacturing process.

Installation of the transmitter on the weapon locates the transmitter parallel to the barrel and registers it axially by the rear attachment adapter which straddles the front sight post. Installation is completed by bringing the flat springs up against the bottom of the rifle barrel and then closing the bowed springs over the round support posts of the flat springs. To remove the transmitter the bowed spring is unsnapped with the thumb and the above procedure reversed.

4.2.1.5 Weight and Center of Gravity

The M16 laser transmitter including its GFE 9 volt battery weighs 25.4 ounces. The effect of this added weight to the transmitter is a shift in the center of gravity (CG) of the weapon toward the muzzle. This shift is shown pictorially in figure 4-20. The CG shift has a minimal effect in the carrying and handling of the weapon.

4.2.1.6 Laser Alignment

As shown in figure 4-21, the M16 laser transmitter is mounted forward of the front sight. It is sufficiently low in height that it does not interfere with the weapon sight line. In the field, the weapon sights are aligned to the laser beam using the arms alignment fixture. Once aligned, the transmitter can be removed and reinstalled with alignment repeatability.

4.2.1.7 Dry Fire Mode

The M16 laser transmitter is provided with a dry fire mode of operation (no blanks). To operate the weapon simulator in this mode, the trigger assembly must be attached to the weapon and connected to the transmitter. Figure 4-22 shows the weapon with the trigger switch installed.

The switch portion of the trigger assembly is a trigger overlay switch that slides over the normal weapon trigger (see figure 4-23). The laser is fired by squeezing the trigger in the normal manner.

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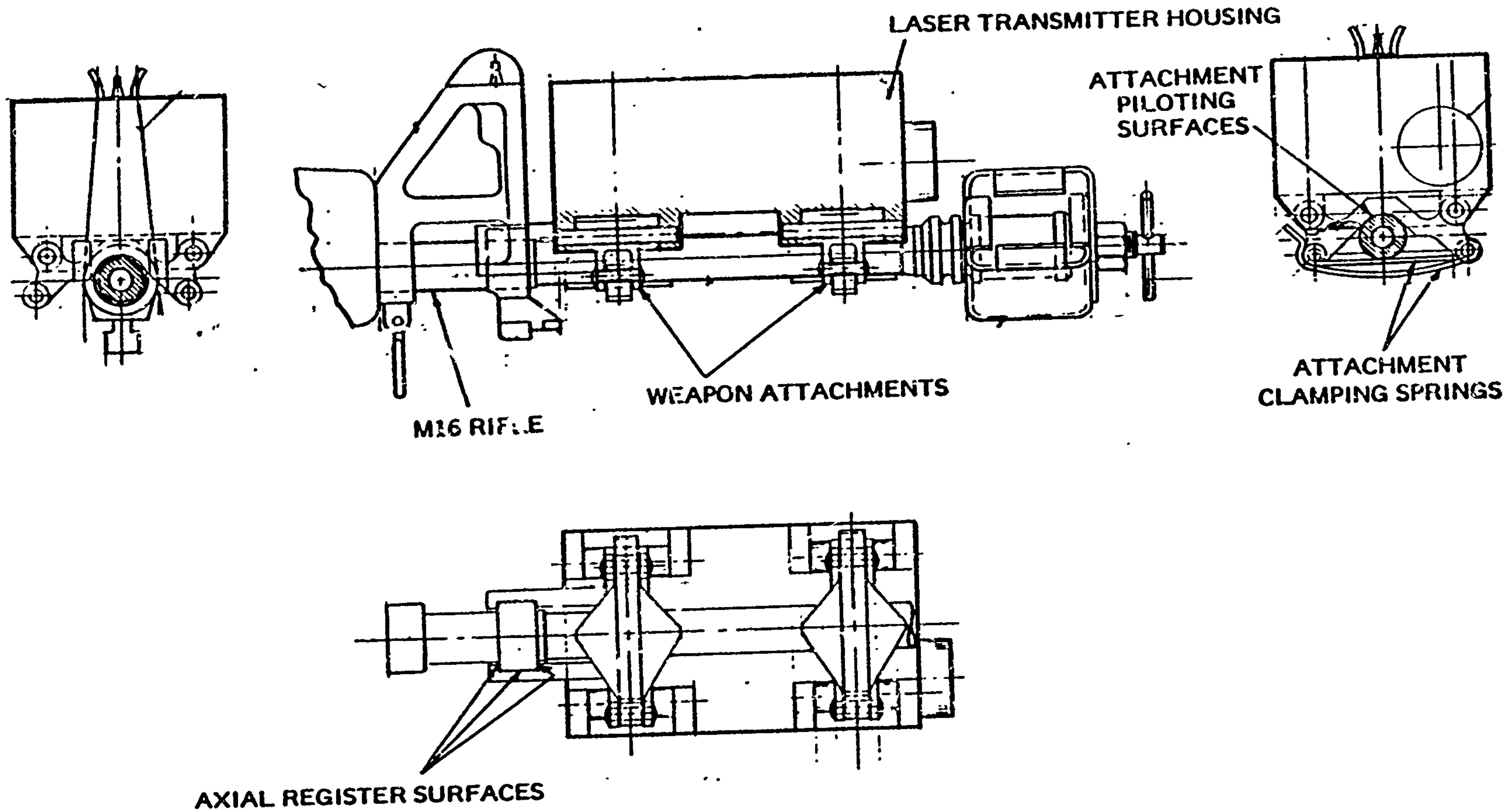

Figure 4-18. M16A1 Laser Transmitter Weapon Attachment

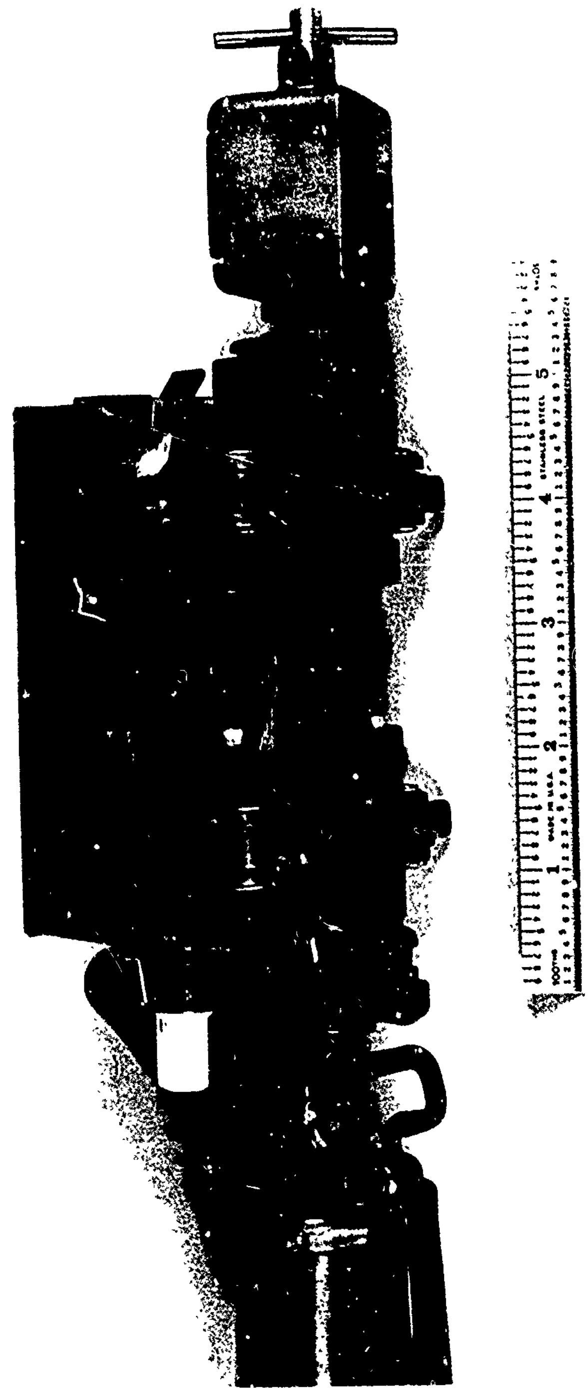

Figure 4-19. M16 Laser Attachment

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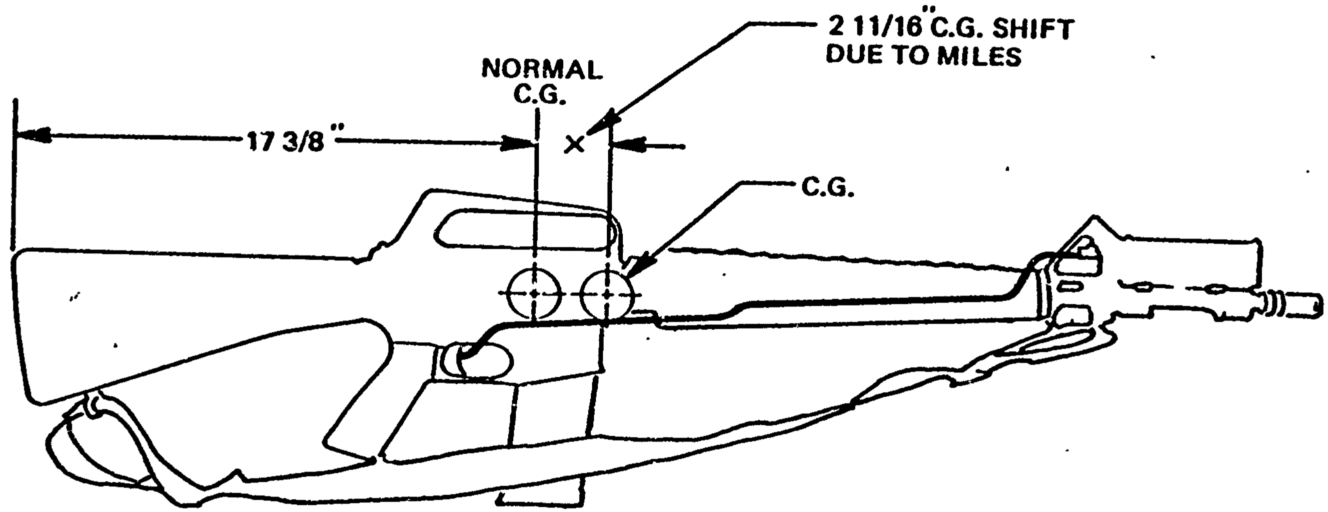

WITH 30 ROUND MAGAZINE 9#, 10.4 OZ.
TOTAL INCLUDES 25.4 OZ. MILES TRANSMITTER

Figure 4-20. M16A1 Rifle Center of Gravity

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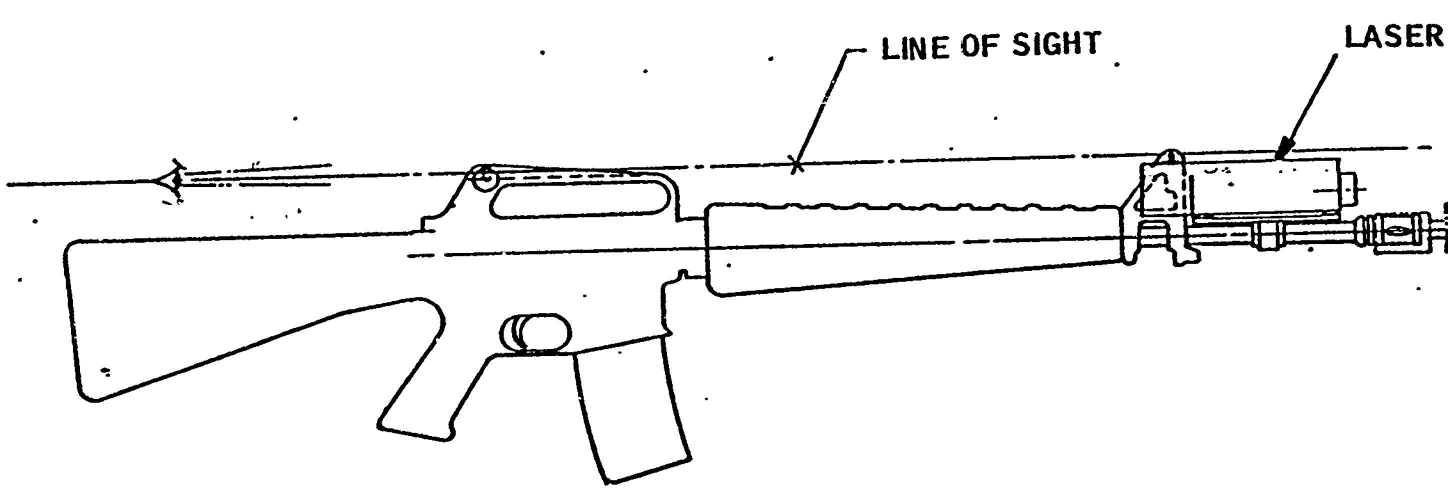

Figure 4-21. M16A1 Rifle Laser Beam Weapon Alignment

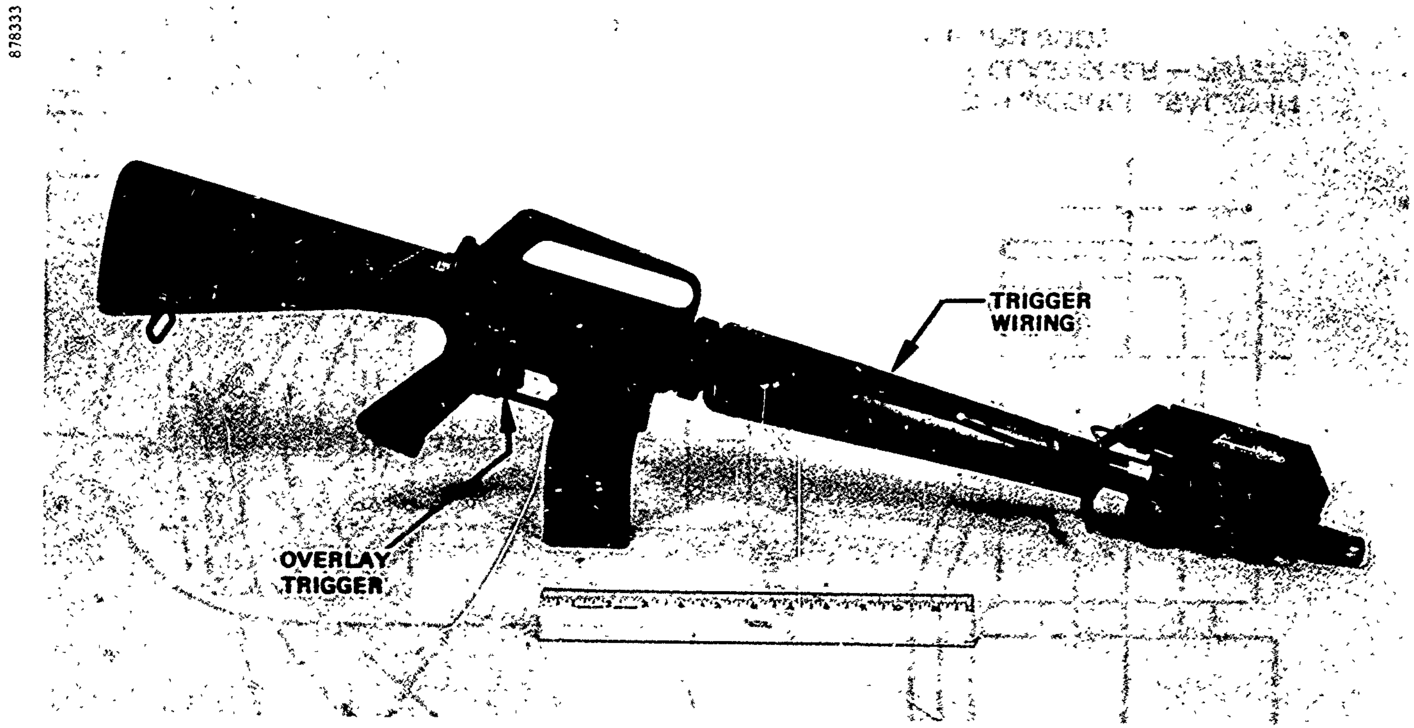

Figure 4-22. Trigger Wiring Installation

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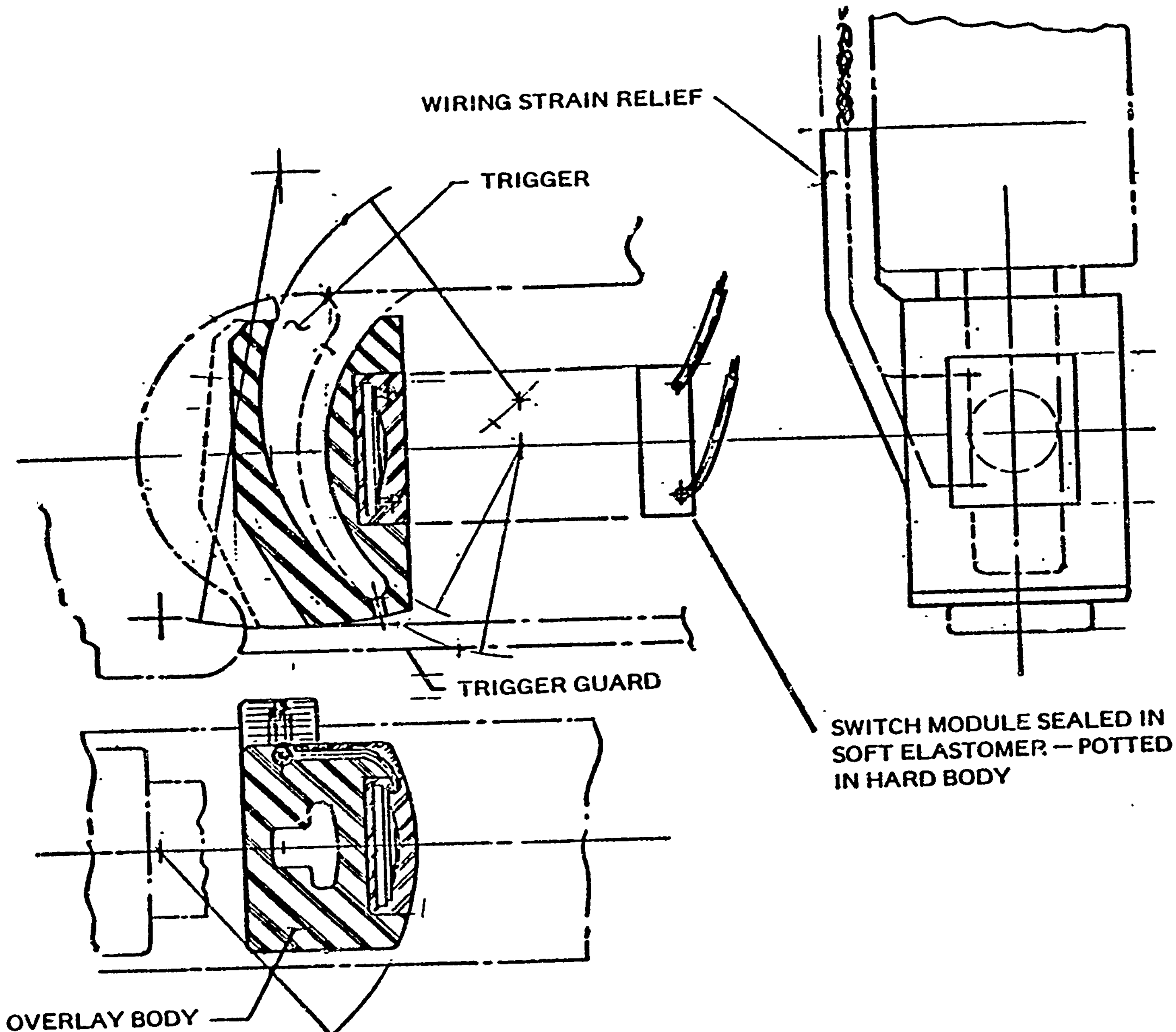

Figure 4-23. M16 Transmitter Trigger Overlay Switch

The laser transmitter must be turned on by the Controller in the dry fire mode. This is done as follows:

a. Insert Controller key in the transmitter weapon key receptacle and switch to the ON position.

This operation turns the weapon on and supplies it with a basic load of 210 rounds of ammunition (30 rounds per magazine). Engineering Development Models required a second operation - a single squeeze of the trigger. *

Firing mode selection is made by a switch on the rear of the transmitter. For single shot operation, the switch is turned to SEMI. For rapid fire operation, the switch is turned to AUTO. In the AUTO mode, the laser transmitter fires at a rate of 678 rounds per minute and is burst limited to 30 rounds, the equivalent of a magazine. The trigger must be released before another 30 rounds can be fired. The firing indicator light flashes every time a laser round is fired.

When all rounds are expended. the firing indicator light ceases to flash and the laser will no longer transmit. The laser can be resupplied with a basic load of ammunition only by the Controller with his green key.

4.2.1.8 Blank Fire Mode

The trigger switch assembly is removed and not used when operating in the blank fire mode. In this mode of operation, a microphone senses the blank firing and triggers the laser transmitter each time a round is fired. The total laser rounds are limited only by the number of blank rounds issued to the infantryman.

The M16 blank fire attachment is necessary when firing blanks. It should be oriented on the weapon so that the blast effects are not directed toward the laser transmitter. Some carbon will still collect on the transmitter lens and the lens should be cleaned after every field exercise.

4.2.2 M60, M2, and M85 Machine Gun Transmitters.

These three transmitters are similar to the M16 transmitters with only minor differences. The three primary physical differences are external to the assembly. The first difference is that the machine gun transmitters do not have the "AUTO/SEMI" selector switch. The second is the attachment adapters that provide interface with the weapons. All are different one from another. The mounting of the M60 machine gun is to the weapon barrel as shown in figure 4-24. The M2 and M85 machine guns mount to the external jacket of the weapons shown in figures 4-25 through 4-27. The third difference is the weapon key. Its configuration is identical for the M16 and M60 and is identified by its yellow color. The M2 and M85 weapons are used in vehicles and their keys are different from the keys used in ground weapons. This changed configuration is identified quickly by the orange color of the key. In each case, GFE Blank Fire Adapters, unique to the weapon class, are required. *

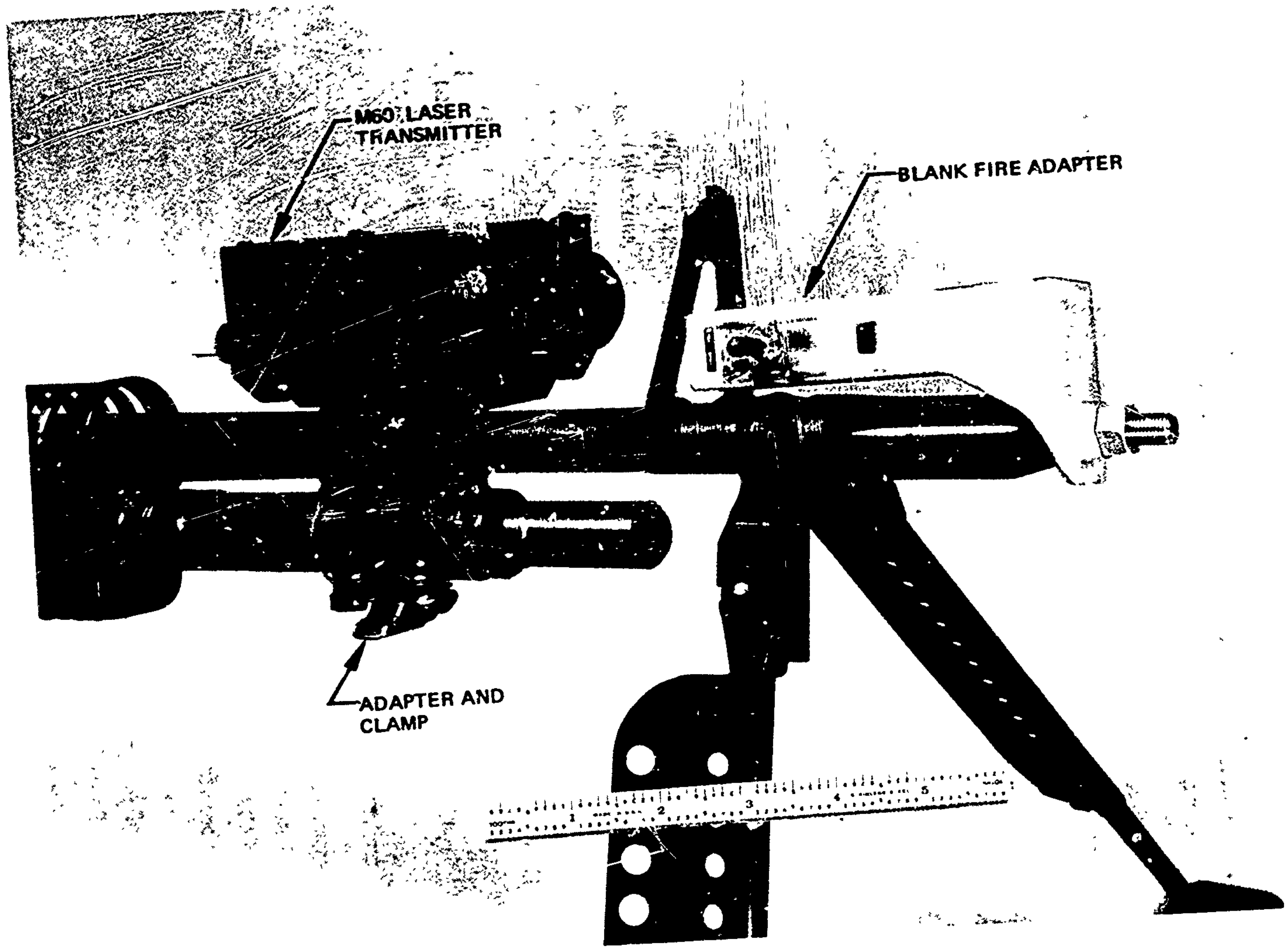

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Figure 4-24. M60 Laser Transmitter Attachment

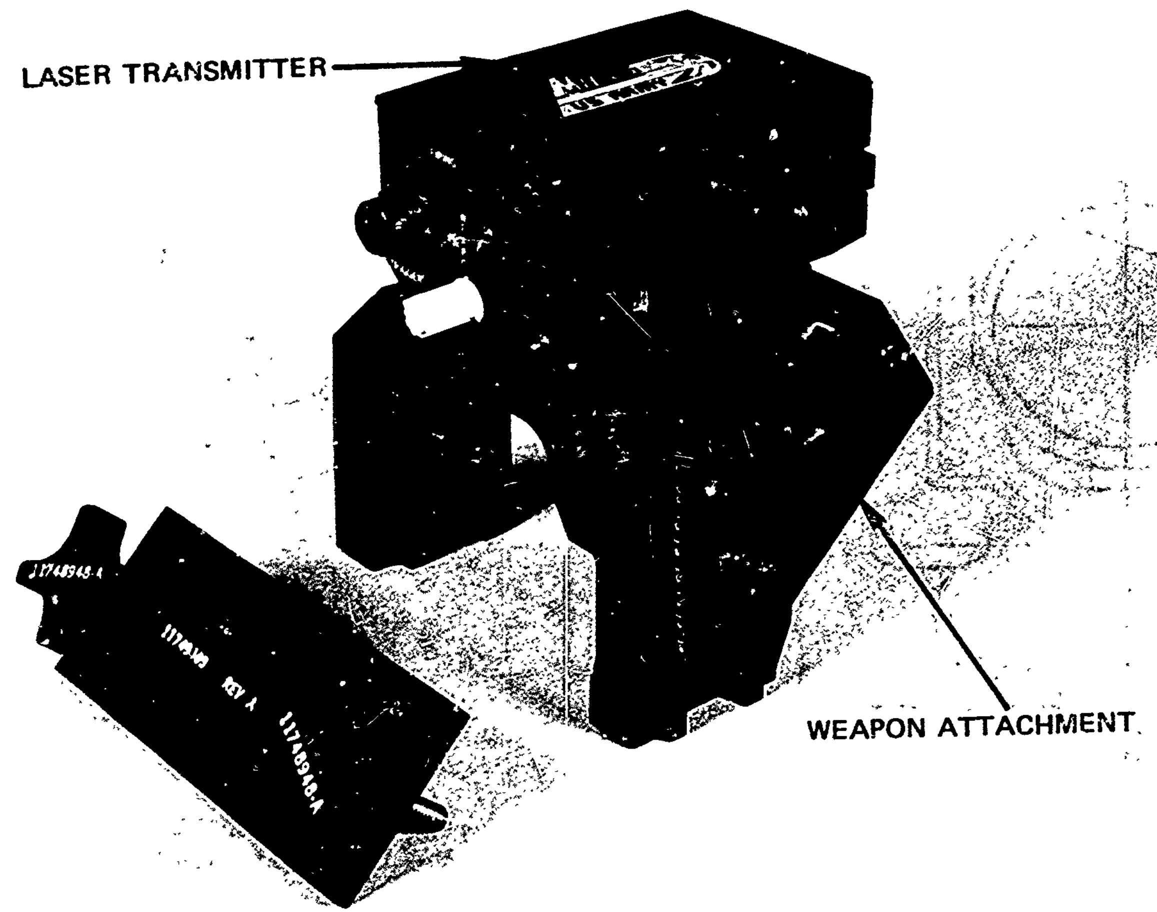

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Figure 4-25. M85 Laser Transmitter and Weapon Attachment

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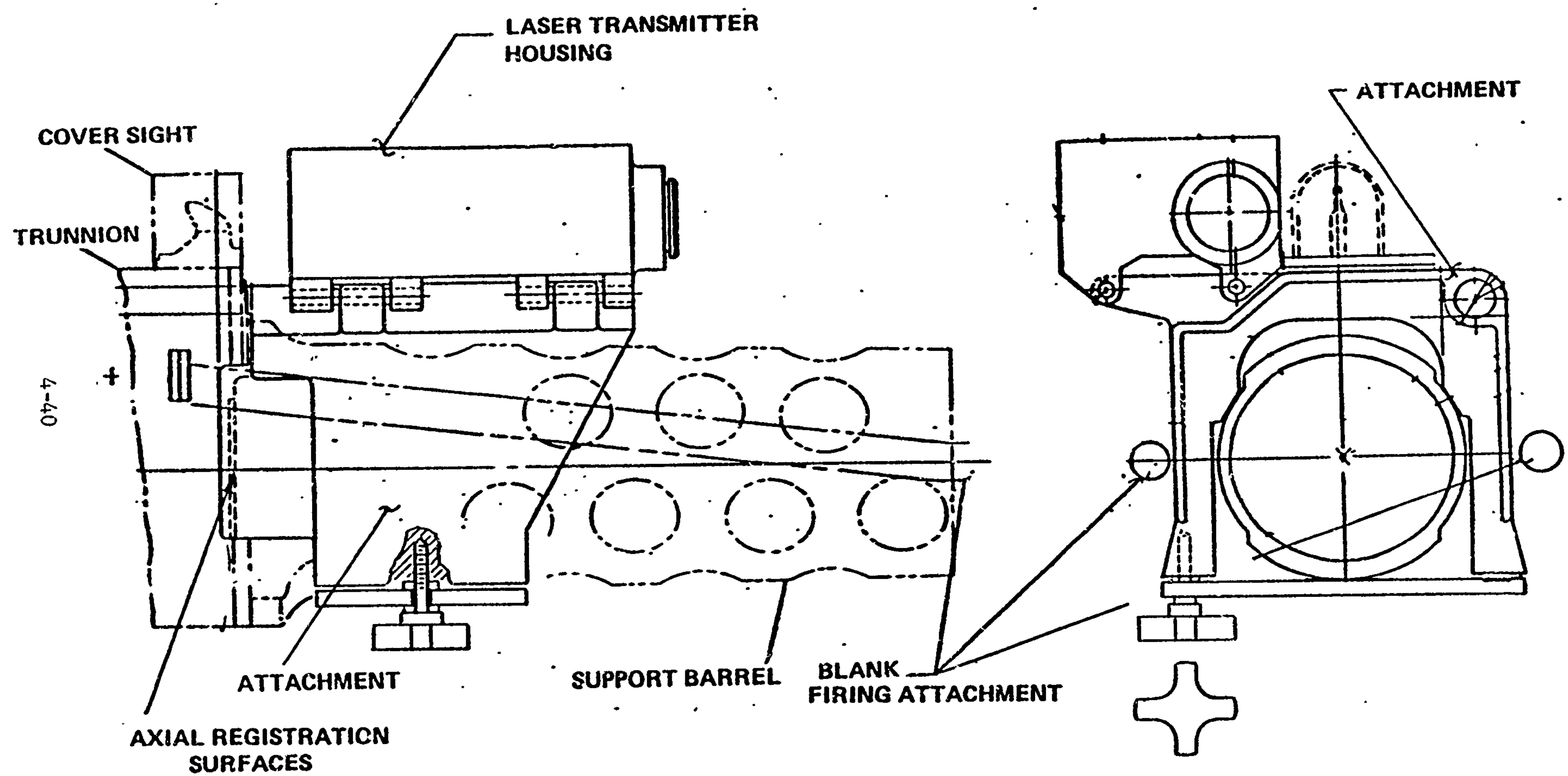

Figure 4-26. M2 Laser Transmitter

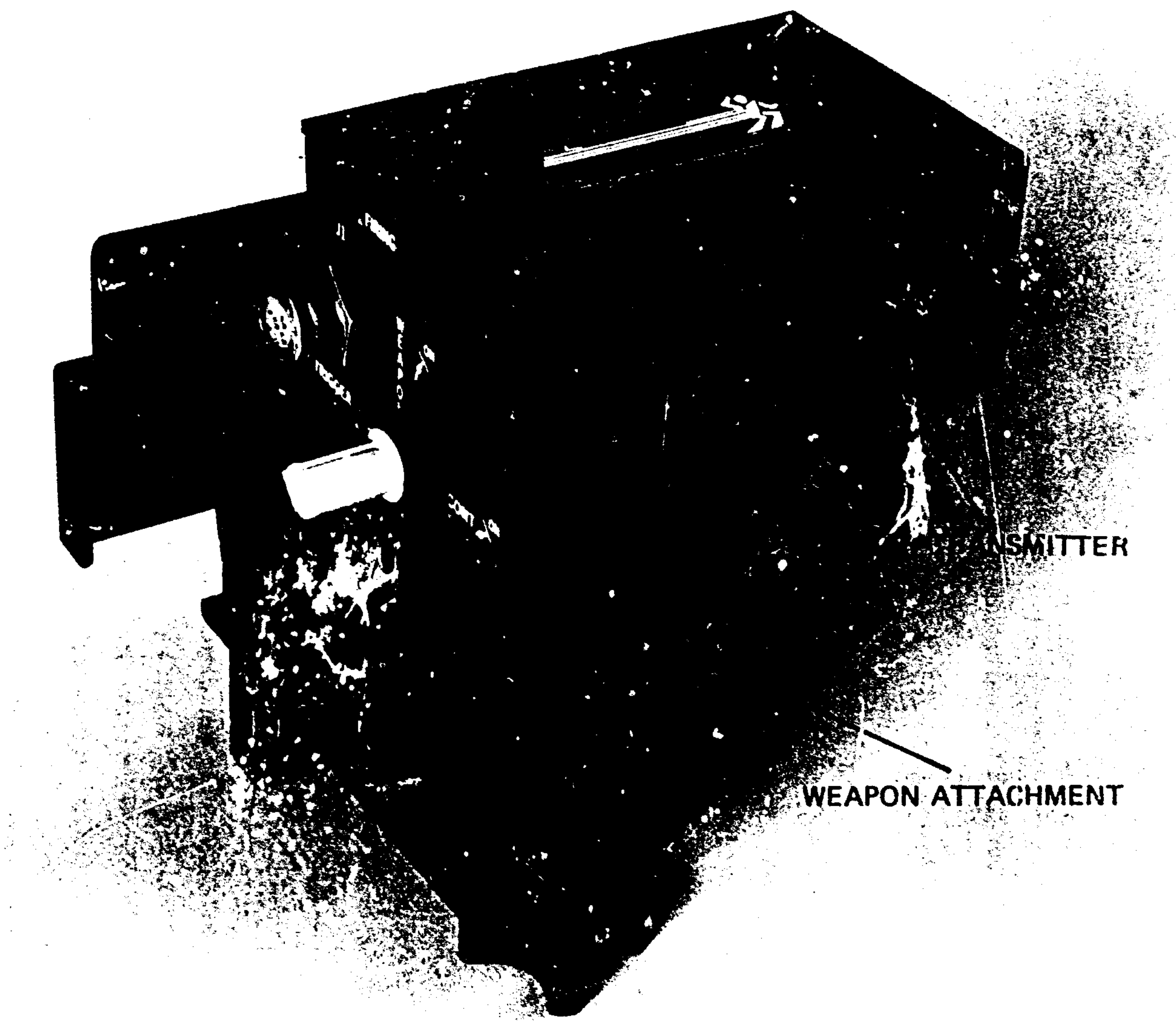

Figure 4-27. M2 Laser Transmitter and Weapon Attachment

Internally, there are slight differences, but only involving component values on the printed wiring boards. The change in component values accommodates the differences in simulation of weapon characteristics which includes the weapon codes. The machine guns have a different basic load of ammunition and different burst limits:

a. M60 - 600 rounds - 200 round burst limit

b. M2 - 1200 rounds - 200 round burst limit

c. M85 - 1200 rounds - 200 round burst limit

4.2.3 DRAGON LASER TRANSMITTERS

The DRAGON transmitter, although functionally much like the previously described laser transmitters, is packaged in an assembly that simulates and replaces the DRAGON sight for tactical training (see figures 4-28 and 4-29). This simulator has a built-in telescope that is factory aligned to the laser transmitter so that no adjustments are required in the field. The tracker simulator mates with a simulated DRAGON launch tube in a manner similar to the normal DRAGON sight. The launch tube assembly contains the ATWESS firing device.

The laser transmitter is operable in two modes (Dry Fire and ATWESS) selectable only by the Controller. Selection is made with the controller key at the DRAGON transmitter weapon key receptacle. ATWESS is the normal mode with Dry Fire used primarily for testing. The Controller must also turn this weapon ON with his key for either ATWESS or Dry Fire mode. In so doing he sets the basic load of 4 rounds for the simulator.

4.2.3.1 Dry Fire Mode

In the Dry Fire mode, the weapon is fired in the normal manner by pressing the thumb trigger release, then squeezing the trigger. The gunner must track the target for a total of 7 seconds to score a hit. There is a one second delay after triggering before laser transmission starts, and the laser transmits for 6 seconds. The ATWESS will fire in the Dry Fire mode if the ATWESS is loaded and armed. However, the ATWESS cartridge is not required in the dry fire mode for the MILES laser transmitter to operate. *

4.2.3.2 ATWESS Mode

In the ATWESS mode it is required to have an intact ATWESS cartridge in the firing chamber and the ATWESS firing device loaded and armed before the MILES laser will operate. The one added operation with ATWESS is to pull out the ARM lever just before firing the DRAGON. When the trigger is squeezed, ATWESS fires immediately. There is a one second delay before laser transmission begins. Again, the gunner must track the target as described above. Before the simulator will fire another laser transmission, a new cartridge must be installed. The laser will not fire with an expended cartridge in the ATWESS firing chamber. Sighting is done in the normal manner.

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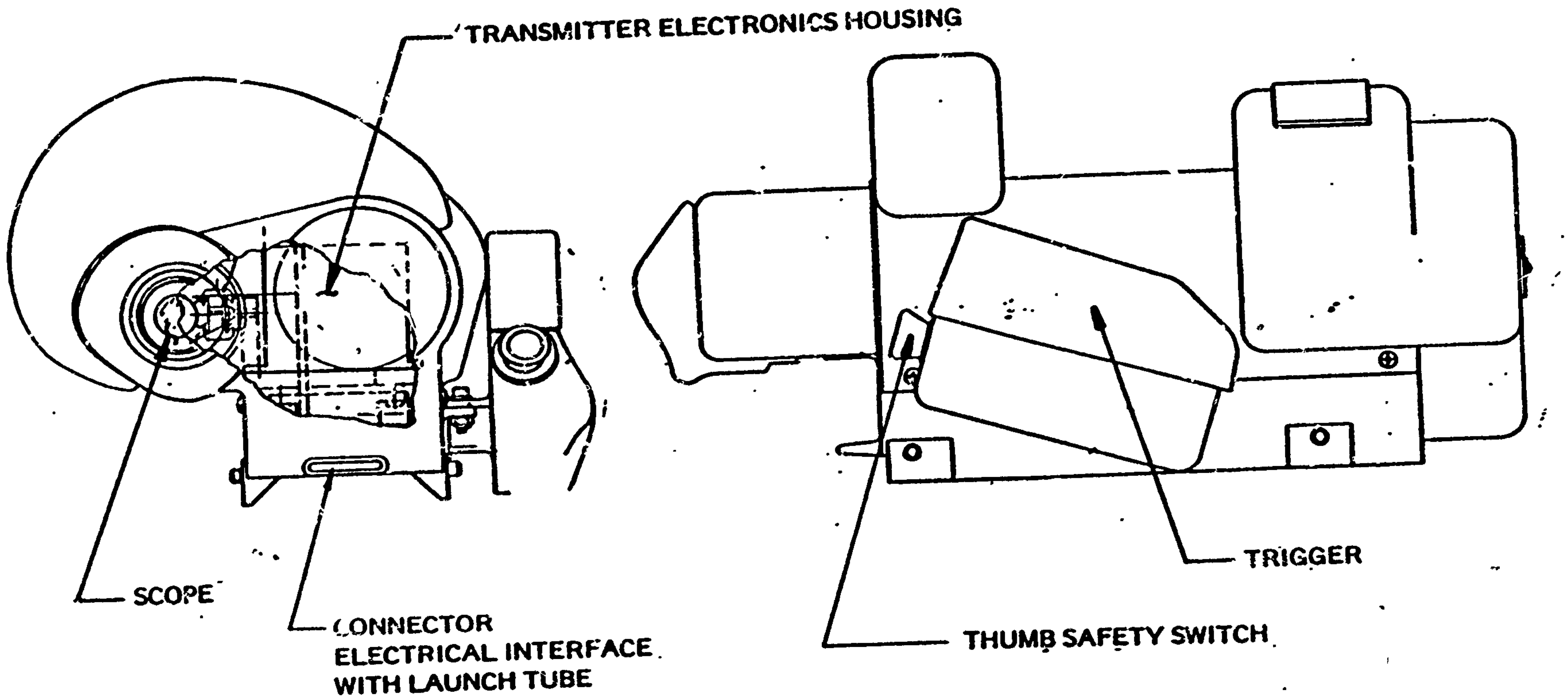

Figure 4-28. Dragon Laser Transmitter Outline Drawing

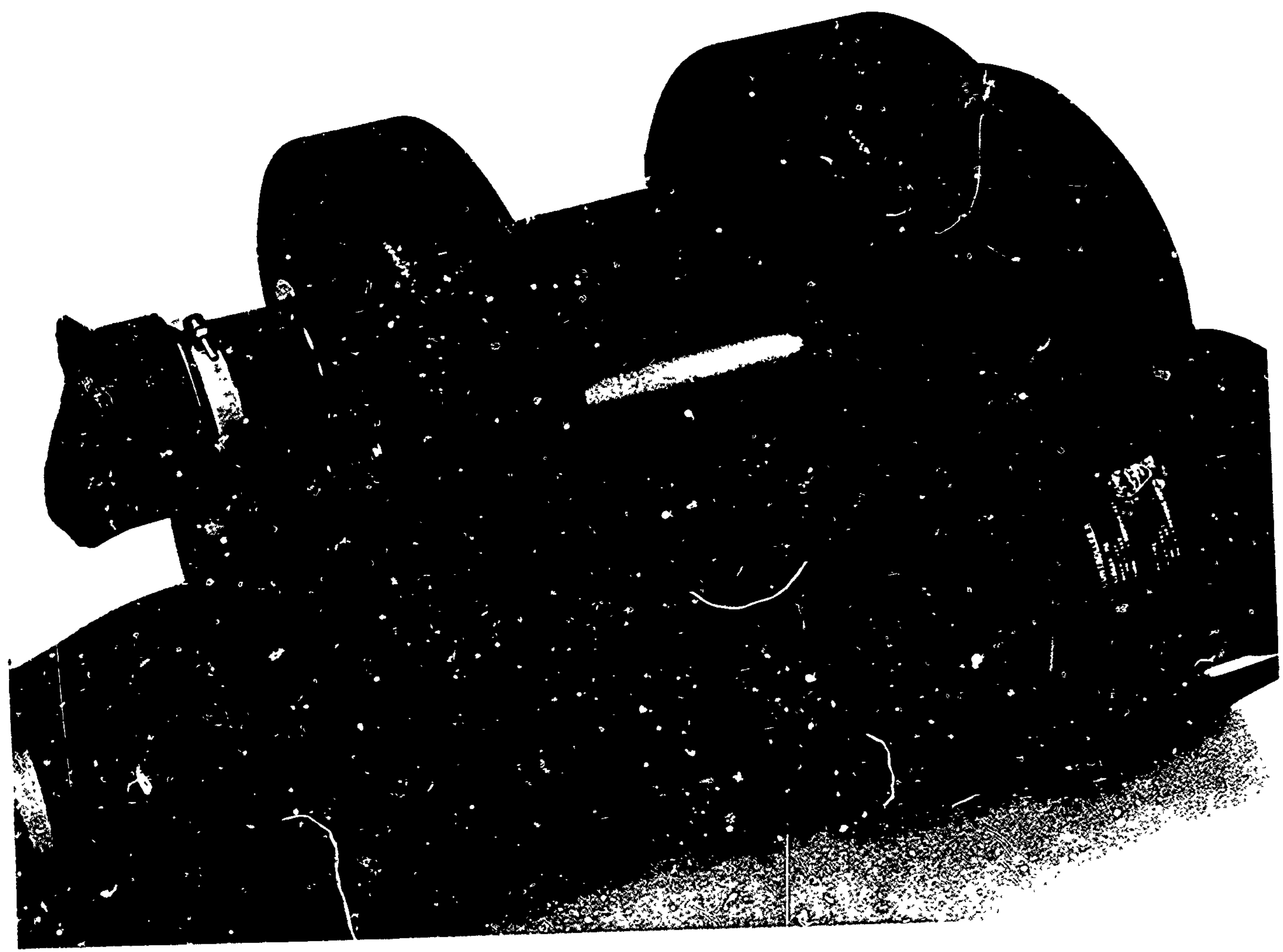

Figure 4-29. Dragon Laser Transmitter

In either mode of operation, the rounds remaining can be checked. This is a feature on DRAGON that the previously described weapons do not have - that is, a rounds count display. By pressing a button, the rounds remaining are shown in the "DISPLAY" window (see figure 4-30).

4.2.4 VIPER LASER TRANSMITTER

As with the DRAGON, the VIPER is similar in its functional design and is packaged in an assembly that simulates and replaces the LAW launch tube (see figure 4-31). The rear of the tube contains the ATWESS firing device.

The VIPER is turned to the "ON" position by the Controller in either Dry Fire or ATWESS mode and is supplied with a basic load of 4 rounds. Its firing rate is 6 RPM. There is no weapon key used in the VIPER for operation. The laser transmitter remains operable until the 4 rounds are expended. It must then be reset by a Controller. VIPER, like the DRAGON has the rounds remaining display.

The VIPER is a fire and forget weapon so there is no time delay or tracking requirement with this rocket simulator. When the trigger is depressed in Dry Fire mode, the laser fires. In the ATWESS mode, depressing the trigger fires the ATWESS and the transmitter simultaneously.

A special ring is provided in the LAW tube front sight (see figure 4-32). This ring is installed at the time of manufacture and is factory aligned with the laser transmitter. The ring is used for sighting since there is no simulation of elevation for trajectory. When ready to fire, the gunner must arm both the VIPER and the ATWESS. The laser will not fire unless a live ATWESS cartridge is chambered and the ATWESS Safe/Arm lever is in the ARM position.

4.2.5 TOW LASER TRANSMITTER ASSEMBLY

The TOW transmitter assembly is designed as a replacement unit for the TOW tracker head. It clamps to the TOW traverse unit with the standard mechanical locking lever. The laser transmitter is located in the area normally occupied by the tracker and a commercial 15 power scope replaces the day sight. The main housing is a casting that closely resembles the actual TOW tracker casting except that six laser detectors for receiving kills or near misses are installed on the sides of the tracker head. The assembly configuration is depicted in figure 4-33. Mounting provision is made for the TOW night sight on the simulated TOW housing.

The laser is factory aligned to the 15X sighting scope so that there is no requirement for alignment or adjustment, other than focus, in the field

Functionally, the TOW transmitter is similar to the DRAGON transmitter described in subsection 4.2.3. It is used with the ATWESS which is packaged in an expended TOW launch tube. Firing is performed in the normal manner for TOW with the exception that the ATWESS must be armed before the MILES TOW will fire. A system block diagram showing the relationship of the TOW transmitter to its associated system elements is shown in figure 4-14.

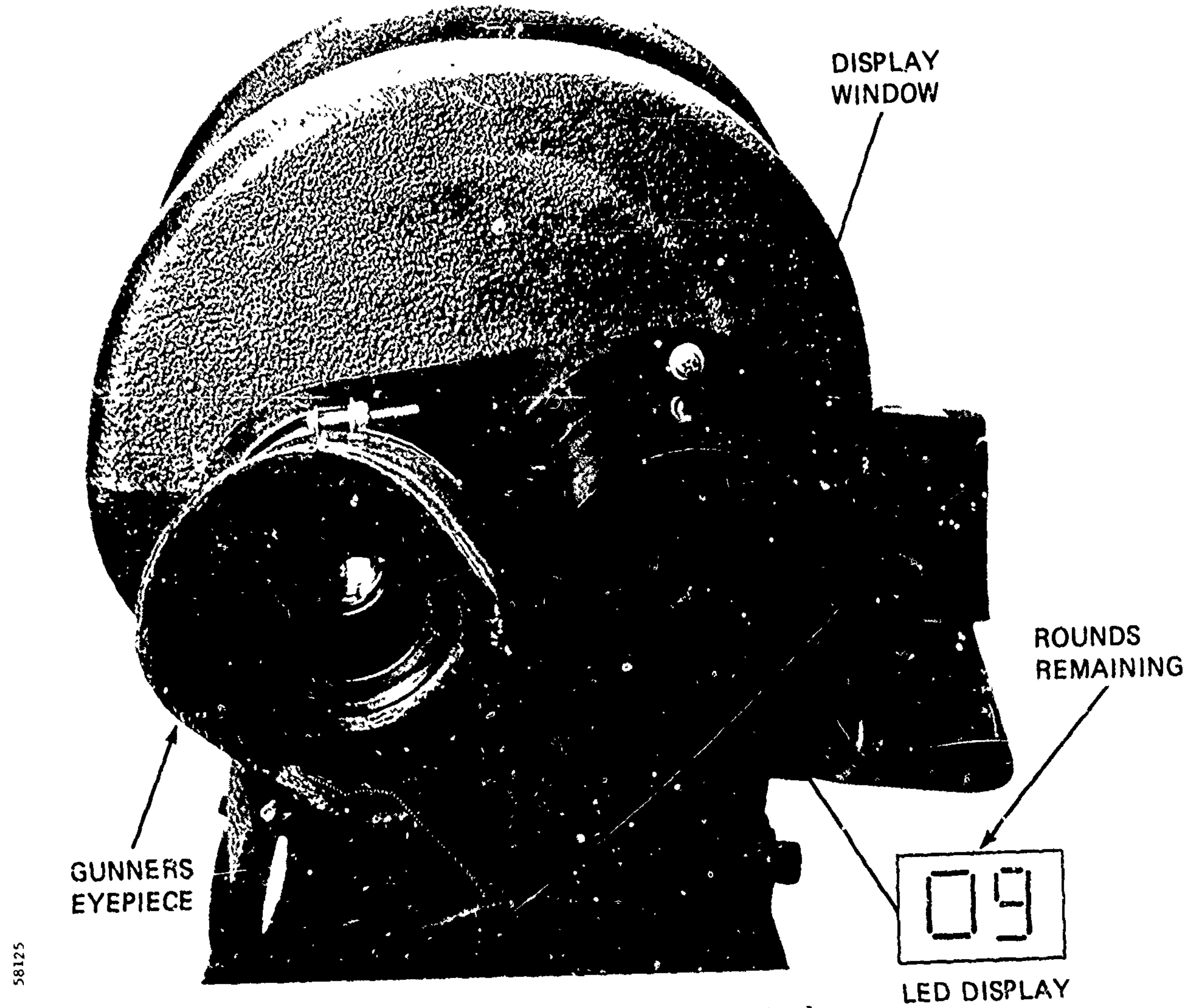

Figure 4-30. Dragon Rounds Count Display

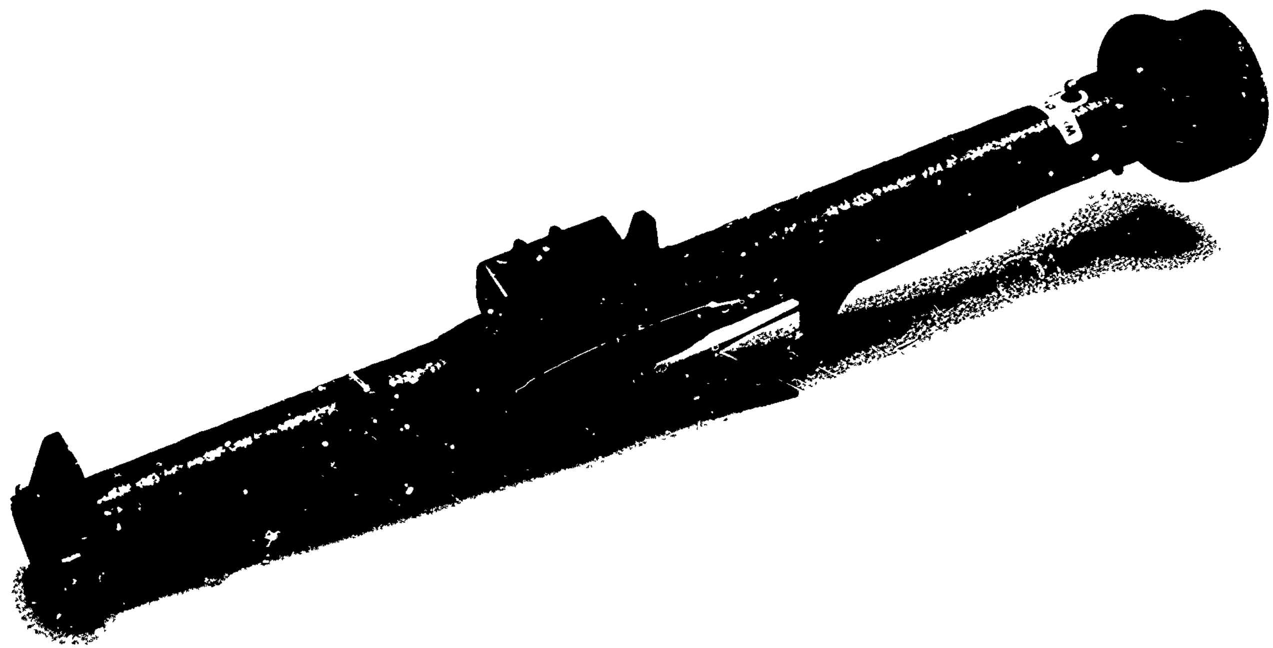

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Figure 4-31. Viper Laser Transmitter

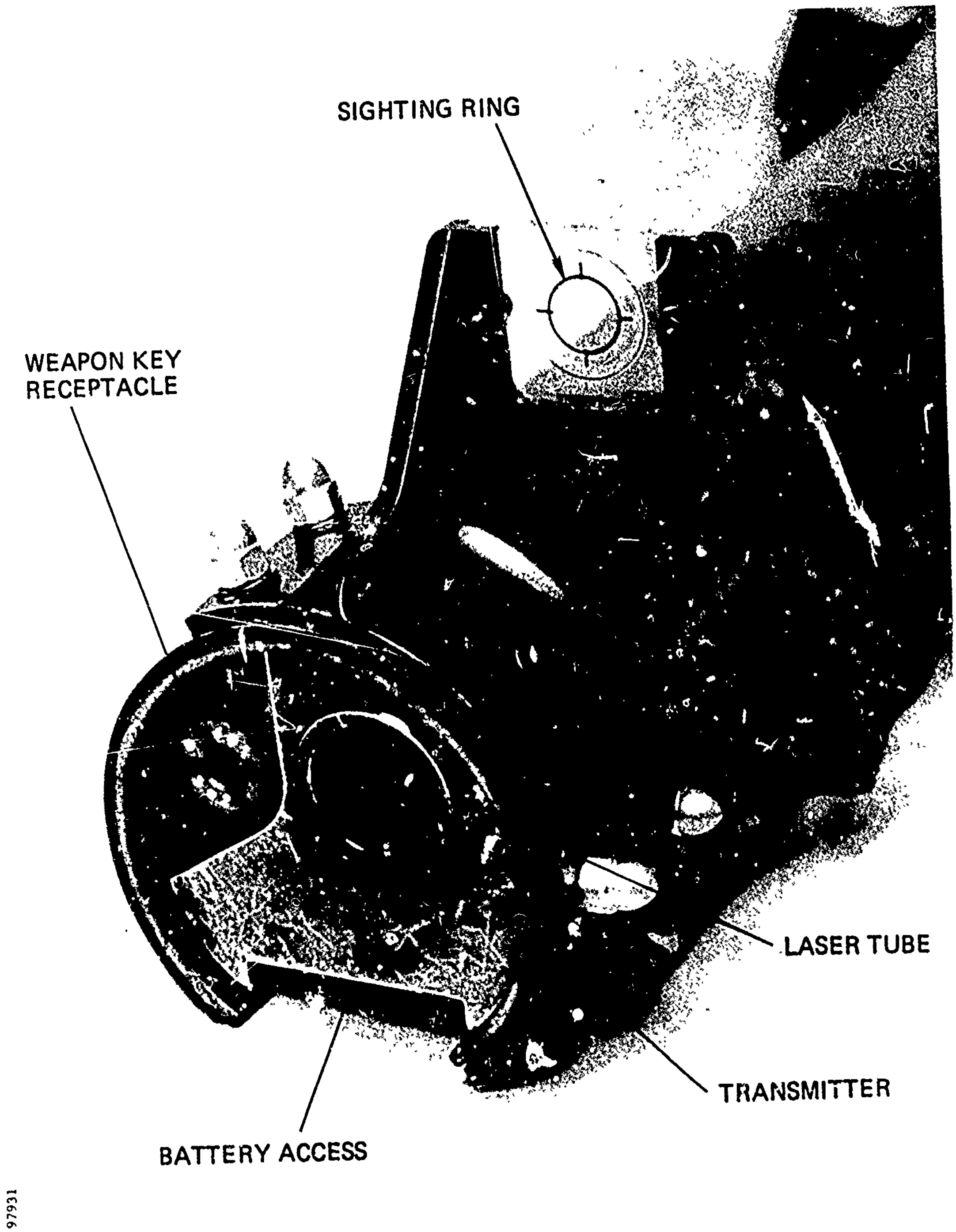

Figure 4-32. Viper Sighting System

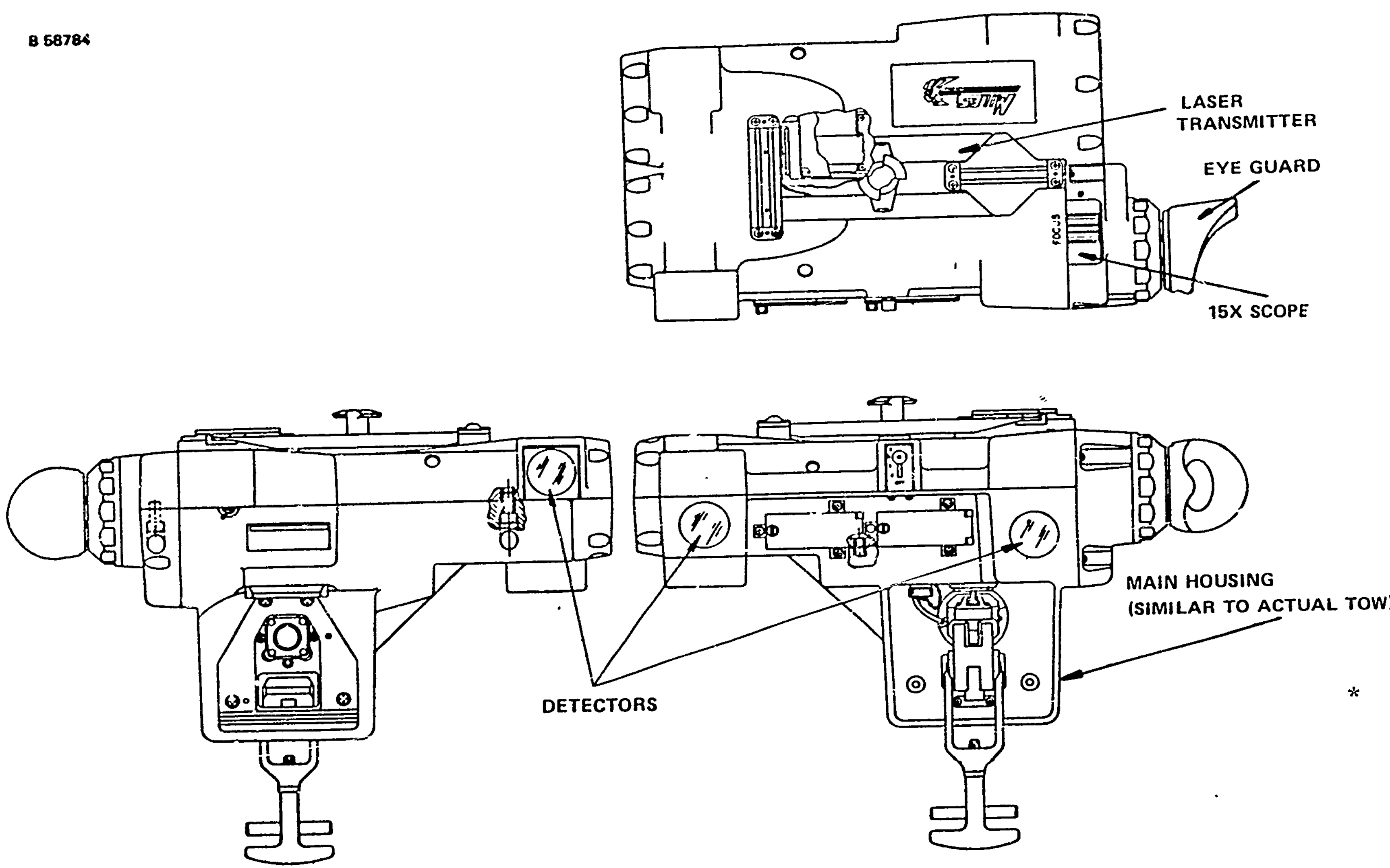

Figure 4-33. TOW Missile Laser Transmitter

*

On trigger depression the ATWESS fires immediately. There is then a 1 second delay before the MILES transmission begins. Since the TOW is a tracking missile, 10 seconds of target tracking time are required. The last 2 seconds are weighted equally with the first 2 seconds in determining a hit.

4.3 DEPENDENT LASER TRANSMITTERS

Unlike the independent laser transmitters, the dependent laser transmitters require the Loader's Control Assembly (LCA), Combat Vehicle Kill Indicator (CVKI), battery box, and interconnecting cabling to operate as a part of the vehicle systems in which they are used. Power is supplied by the 12 volt battery pack and routed to the transmitters via the LCA. The LCA performs the complete logic control function for the dependent laser transmitters. This includes automatic weapon disablement when the vehicle is determined by the LCA to be "killed."

These transmitters are functionally similar to the ones previously described except that part of the electronics is located in the LCA and the batteries are in the battery box. This division of functions also causes a repackaging of each of the three dependent transmitters. Figure 4-34 shows the typical dependent transmitter in its relationship to the other components of a vehicle simulator system. Figure 4-35 is a block diagram typical of the dependent laser transmitters.

4.3.1 105 mm/COAX LASER TRANSMITTER ASSEMBLY

The 105 mm/Coax transmitter assembly is packaged to mount in the chamber of the 105 mm gun on the M60A1 and M60A3 tanks. The assembly contains two laser tube assemblies, one for the 105 mm main gun and one to simulate the 7.62 mm coaxial machine gun. A telescope is packaged as a part of the assembly and the two laser tubes and telescope are factory aligned to each other. Tolerances of alignment are:

a. Coax to 105 mm = ± 1.5 mrad

b. 105 mm to telescope = ± 0.3 mrad

The assembly is inserted in the gun chamber and locked in place with the mechanism shown in figures 4-36 through 4-39. Another assembly, also shown, is used to mechanically lock the breech in the open position.

Laser/Gun Tube Alignment

The laser and main gun alignment is accomplished in the field by the vehicle crew. A boresight target is selected at approximately 1200 meters or greater and the main gun is pointed until the telescope crosshairs in the laser transmitter assembly are aligned with the aiming point. The gun is then fixed at that point and the tank weapon sights are adjusted to match the telescope sights.

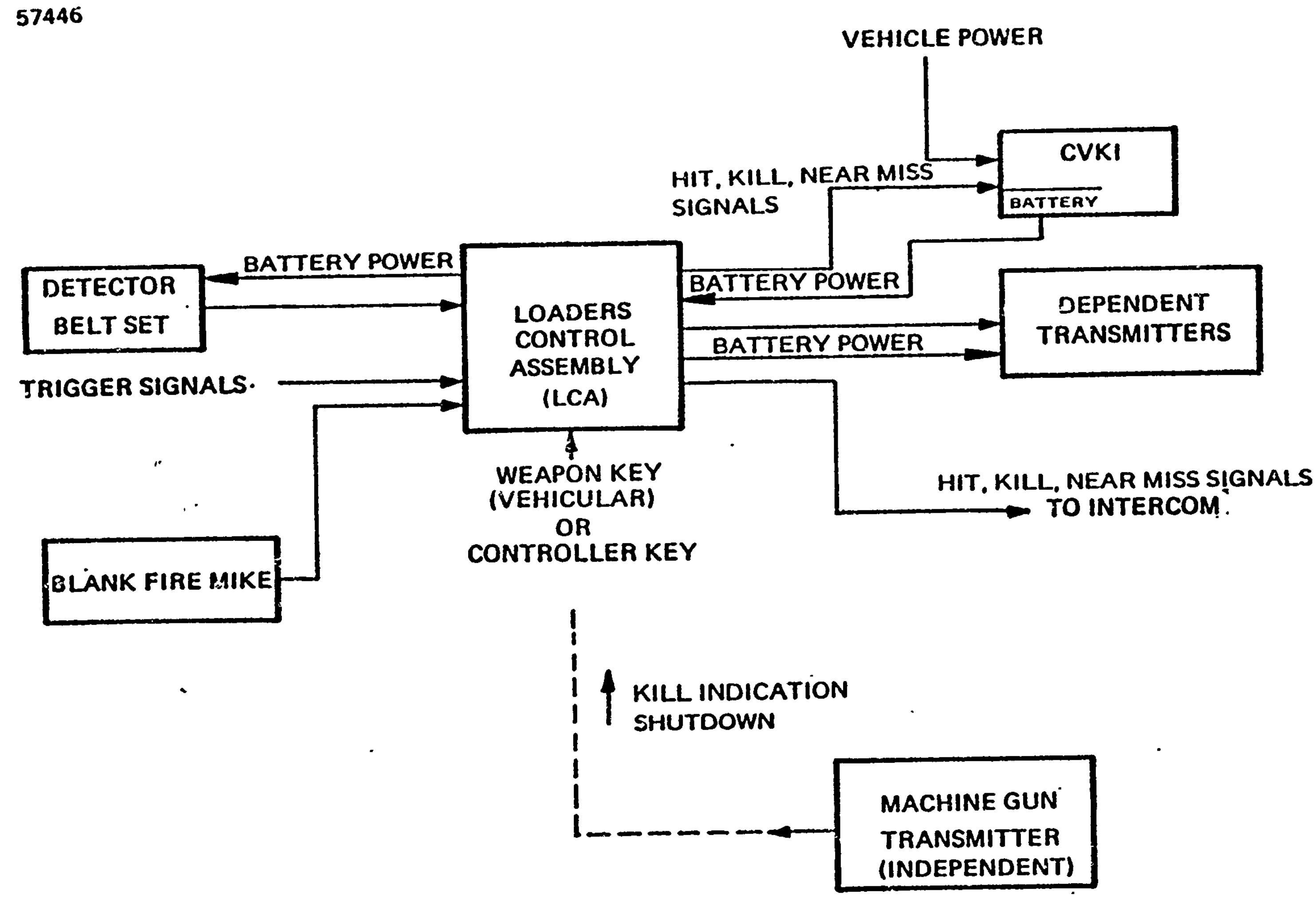

Figure 4-34. VES General Block Diagram

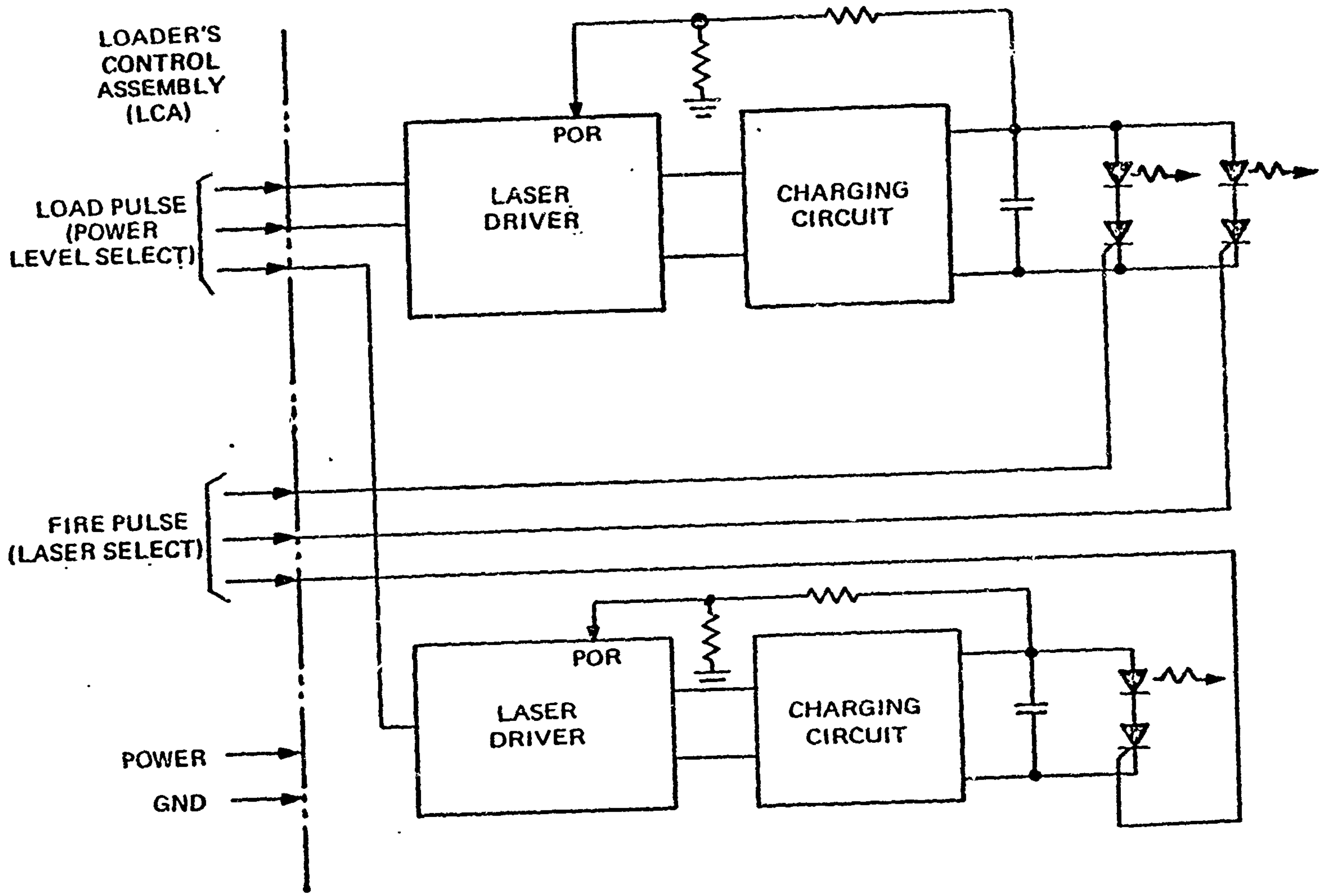

Figure 4-35. Dependent Laser Transmitter Functional Block Diagram

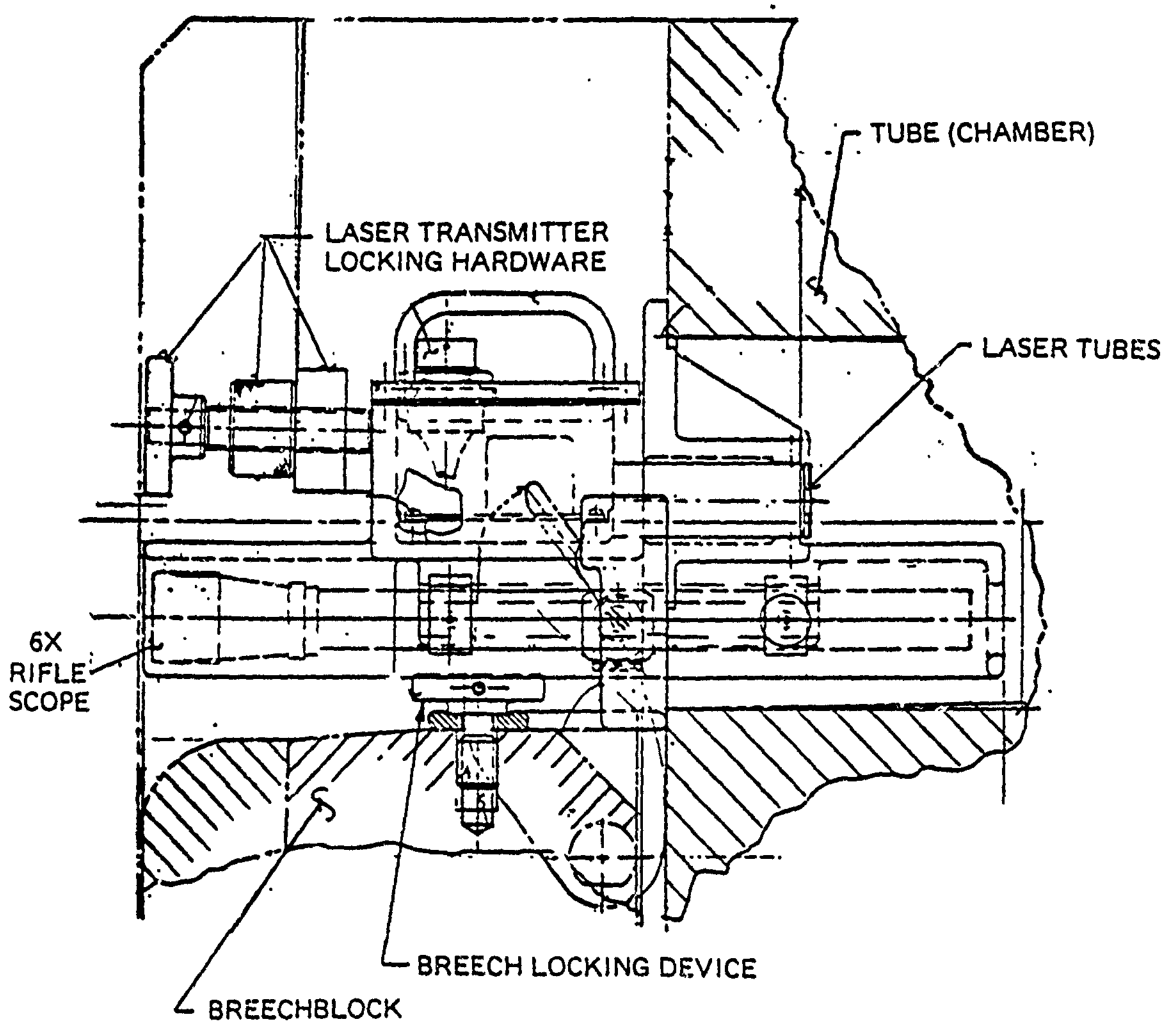

Figure 4-36. 105mm Laser Transmitter - Side View

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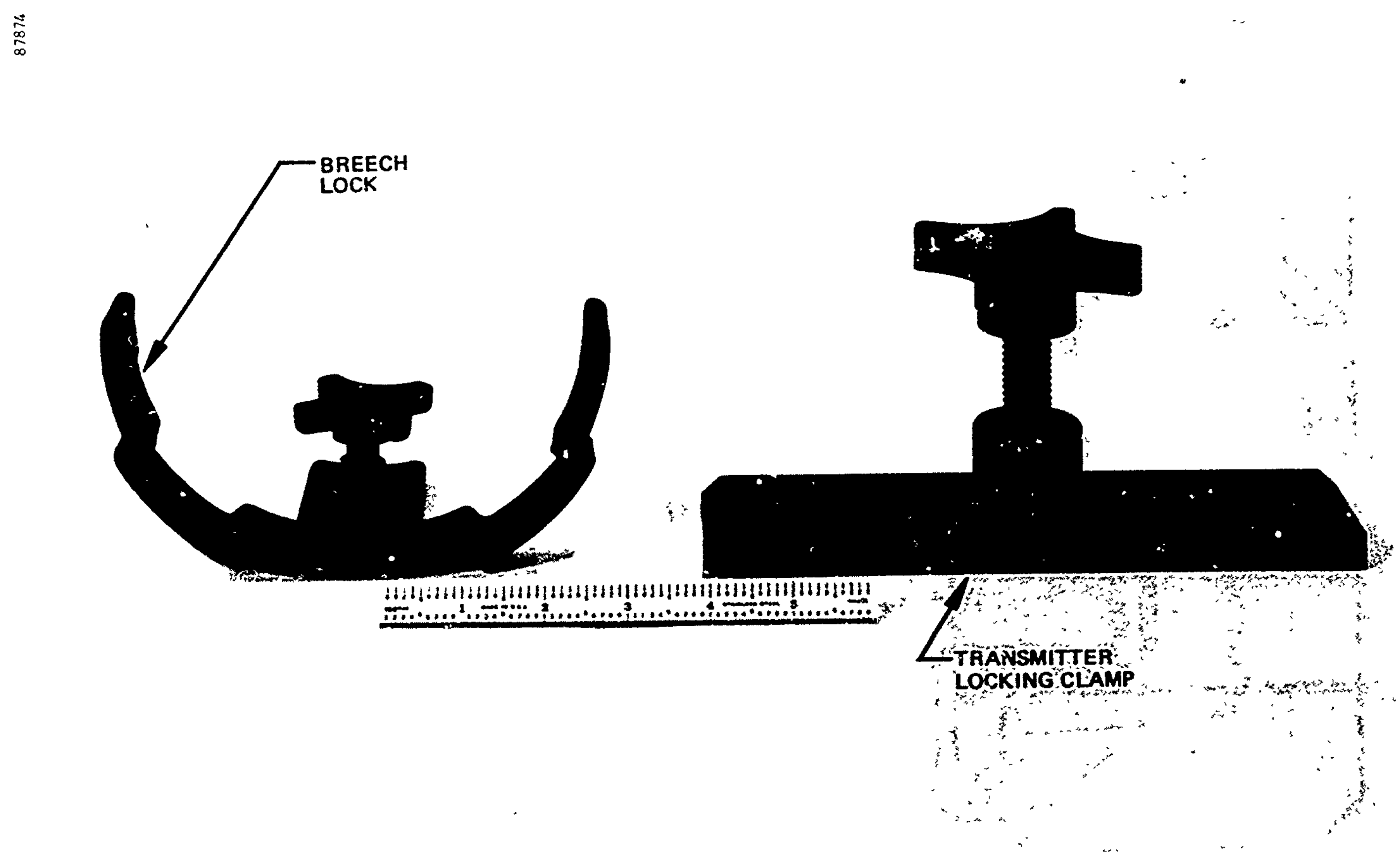

Figure 4-37. 105 mm Locking Mechanisms

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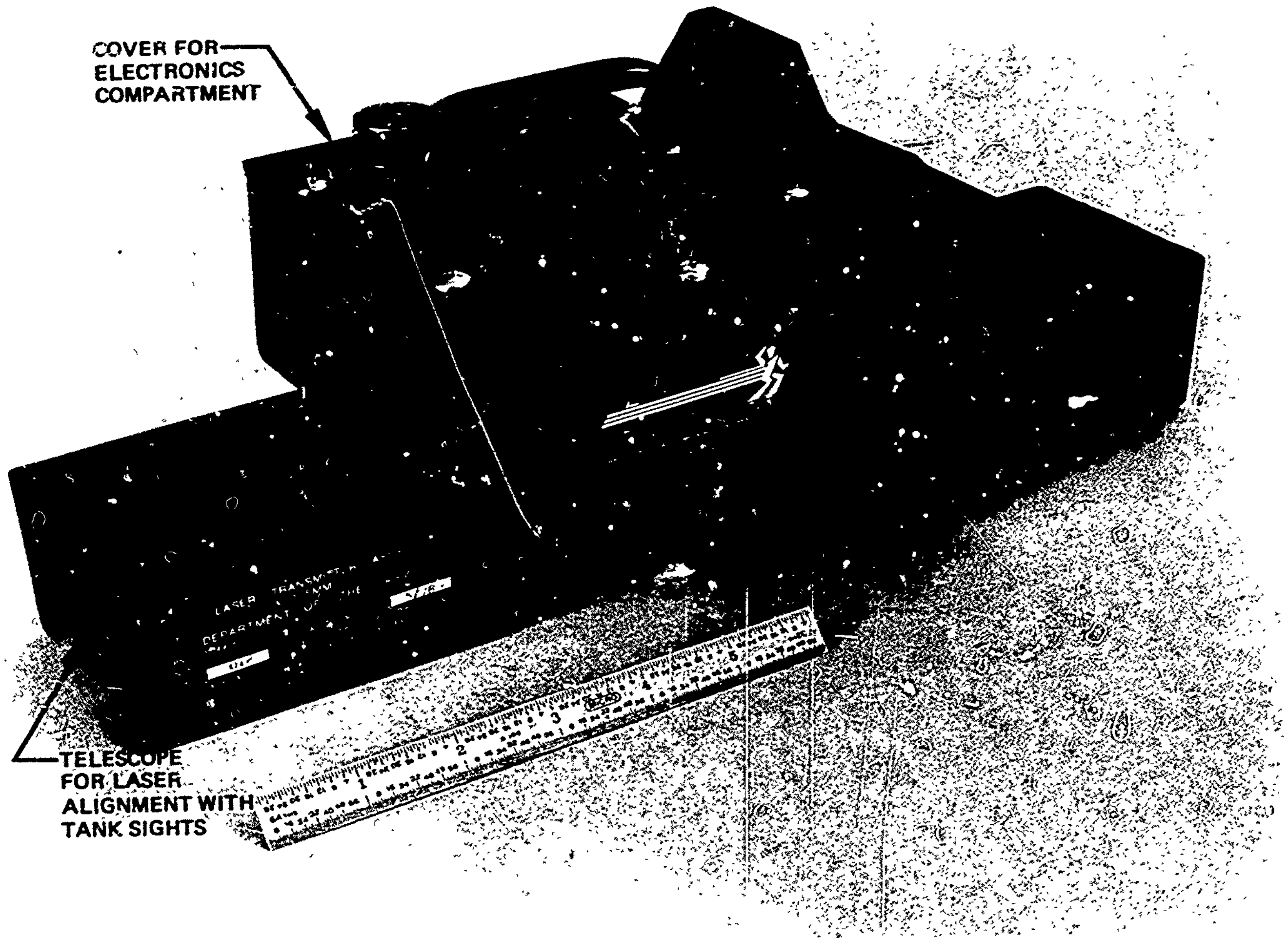

Figure 4-38. 105 mm Transmitter Assembly

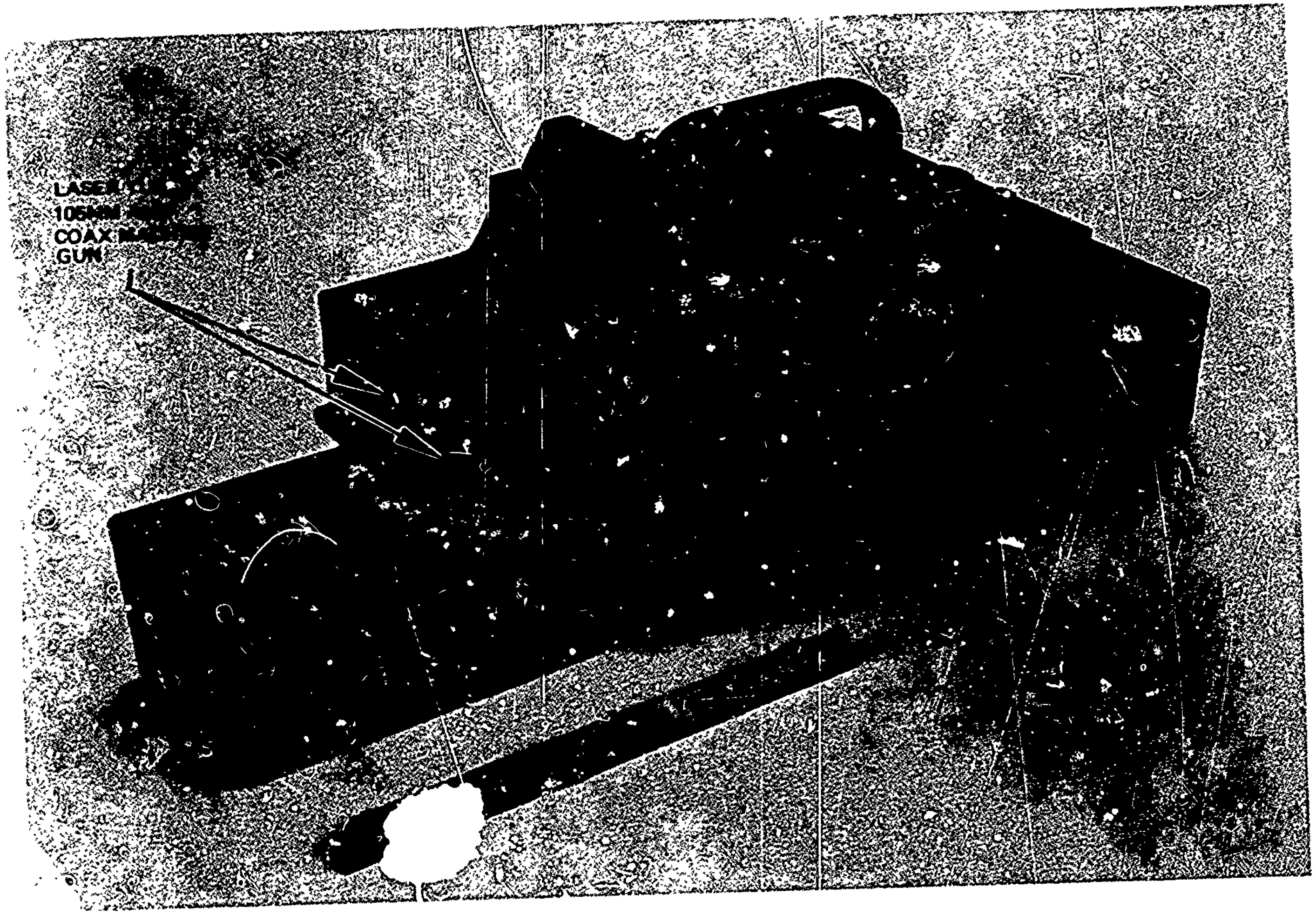

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Figure 4-39. 105 mm Transmitter Assembly

4.3.2 152 mm/COAX/SHILLELAGH LASER TRANSMITTER ASSEMBLY

The 152 mm/Coax/Shillelagh transmitter is packaged to fit into the main gun chamber on the M60A2 tank and the M551 AARV vehicle. The assembly contains three laser tube assemblies, one each for the 152 mm main gun, coax machine gun, and Shillelagh missile simulators. A 6x telescope is packaged as part of the assembly and the three laser tubes and telescopes are factory aligned to each other. Tolerances of alignment are:

a. Coax to Shillelagh = ±0.5 milliradian

b. 152 mm to Shillelagh = ±1.0 milliradian

c. Telescope to Shillelagh = ±0.3 milliradian

The assembly is inserted in the gun chamber and locked in place as shown in figures 4-40 through 4-42.

Laser/Gun Tube Alignment

Laser/gun tube alignment is performed in the same manner as previously described for the 105 mm/Coax laser assembly.

In addition a Breech Adapter Plug, attached to the cable, is used to defeat the Shillelagh interlock so that the Shillelagh trigger circuitry may be used for MILES when the breech is open. A lanyard is attached to the adapter plug to prevent it from being inadvertently left in the vehicle. *

4.4 DETECTORS/HIT INDICATORS

Encoded messages sent by the laser transmitters are received by detectors sensitive to the GaAs laser radiation. The received messages are amplified, decoded, and a hit, near miss or kill determination performed. An appropriate signal is then sent to the hit indicator(s) to activate the audio and visual alarms that signify the casualty status.

4.4.1 MAN-WORN LASER DETECTOR (MWLD)

The man-worn laser detector provides detection of laser radiation, logic/decoding, and kill/near miss indication for high fidelity simulation of infantryman vulnerability to all anti-personnel weapon fire. A functional block diagram of the MWLD is shown in figure 4-43.

Since a man is vulnerable to both small and large weapon fire, his decoder allows kills from the complete MILES hierarchy of weapons, including the missiles.

The MWLD is designed to give unrestricted movement to the infantryman and is ruggedized to minimize vulnerability to damage during tactical combat exercises. Every precaution has been taken to reduce the potential for cheating by the infantryman. The man-worn laser detector, shown in figure 4-44, consists of two basic units:

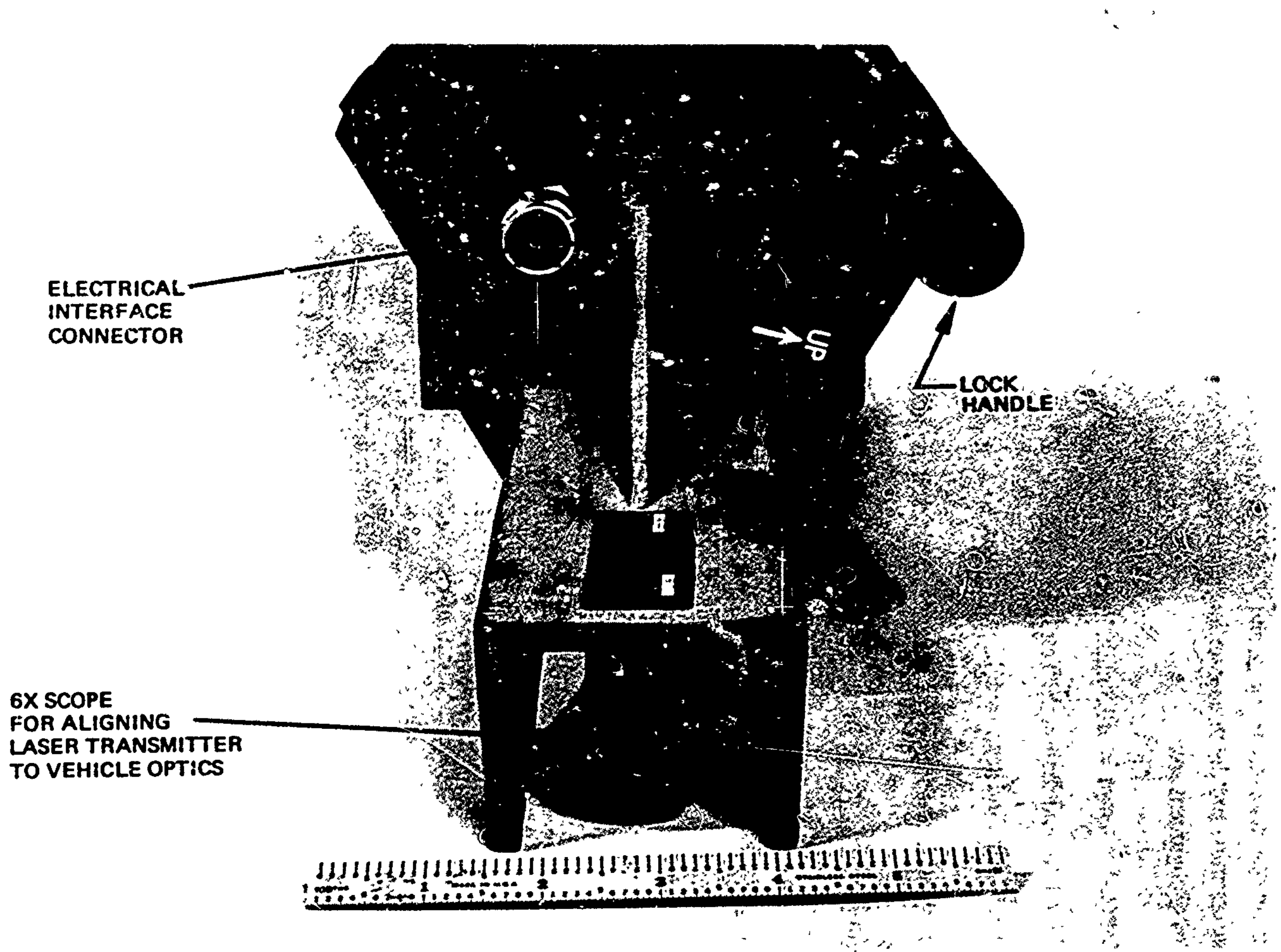

Figure 4-40. 152 mm Laser Transmitter

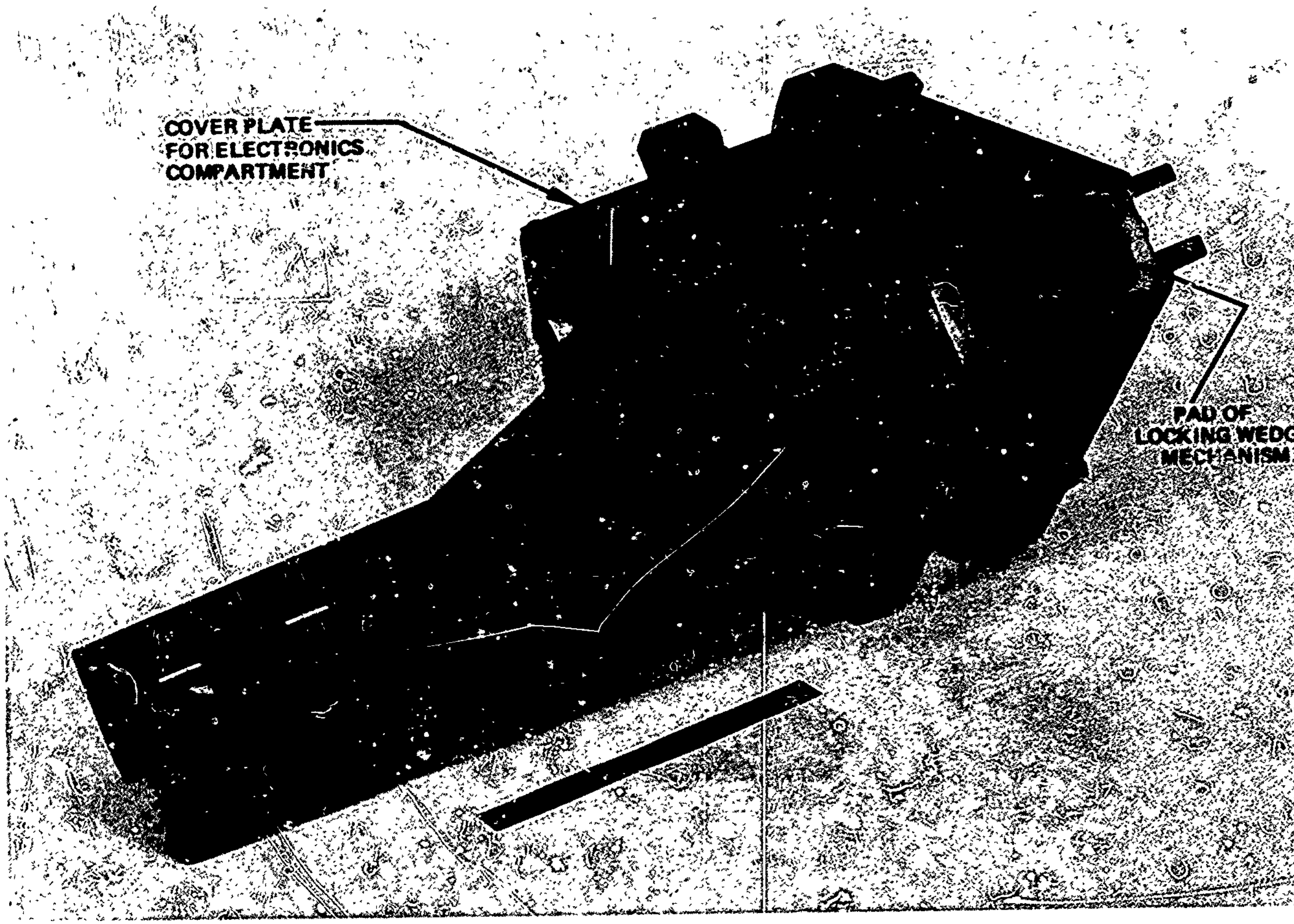

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Figure 4-41. 152 mm Laser Transmitter

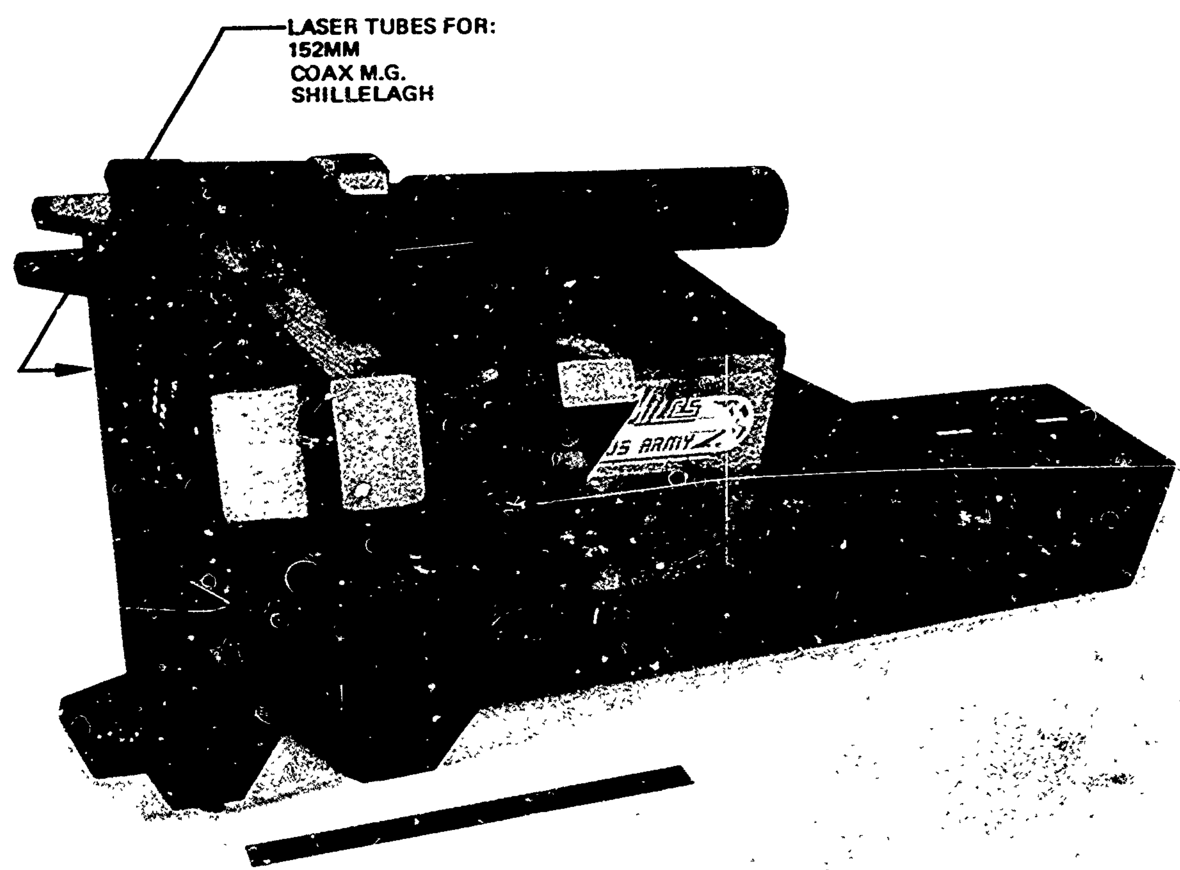

Figure 4-42. 152 mm Laser Transmitter

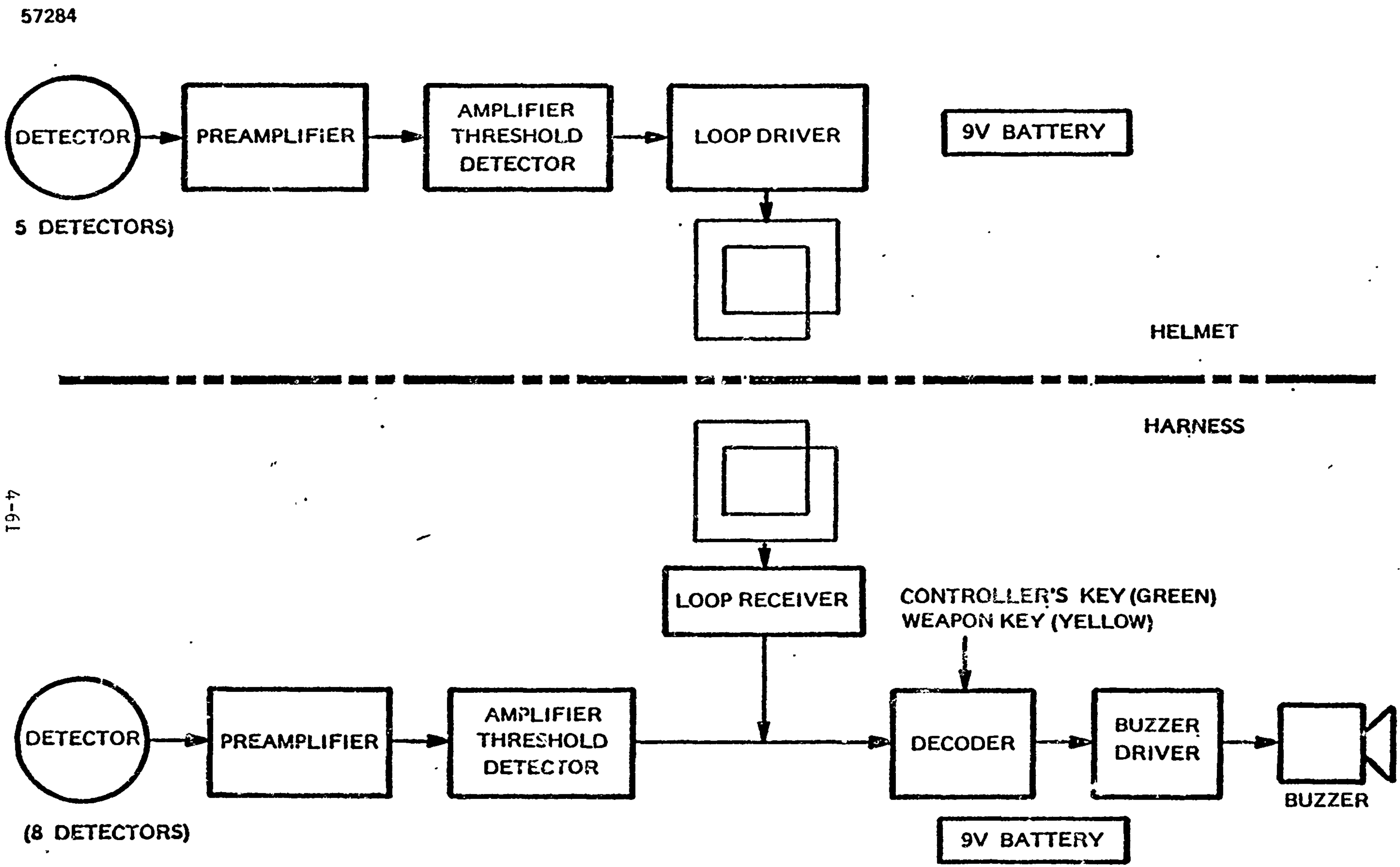

Figure 4-43. Man Worn Laser Detector Block Diagram

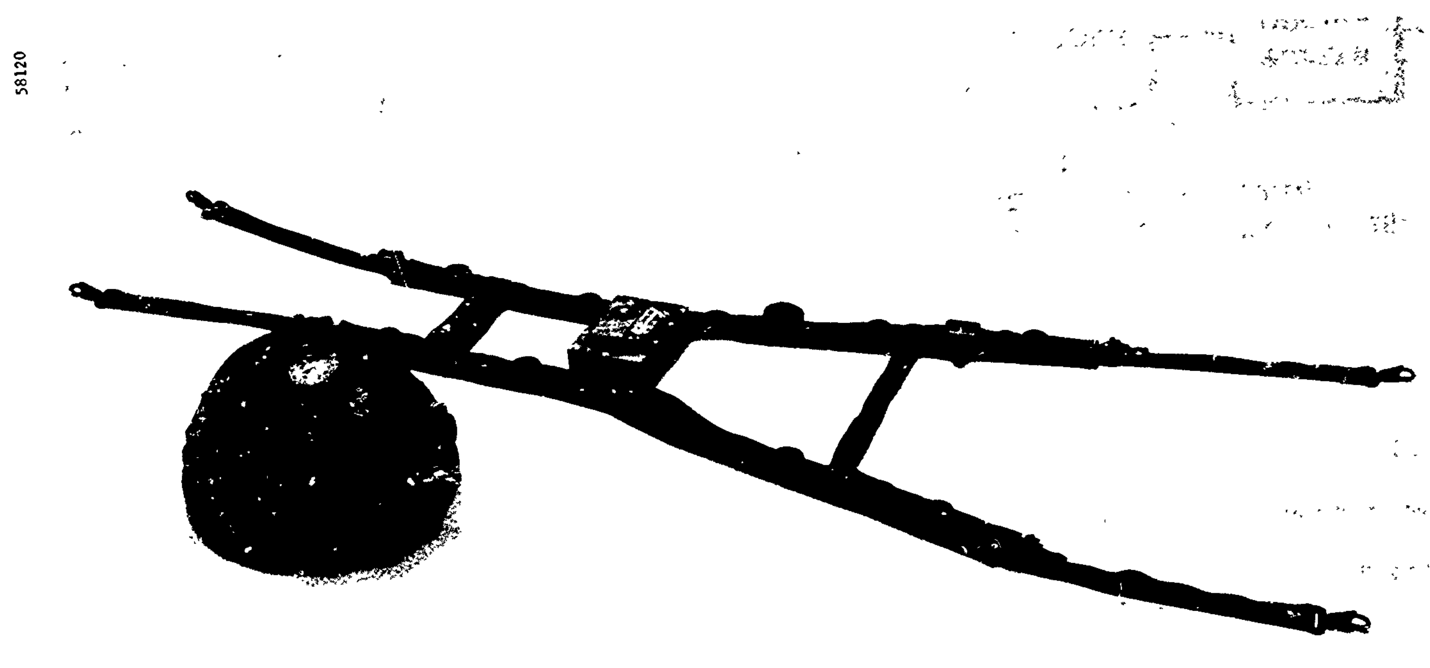

Figure 4-44. Man-Worn Laser Detector

a. Helmet detector assembly (5 detectors)

b. Harness detector assembly (8 detectors)

4.4.1.1 Helmet Detector Assembly

The helmet strap fits snugly on a standard issue steel helmet and can be used with or without the camouflage cover. The helmet strap assembly is shown in figure 4-45. Since the helmet strap assembly is olive drab in color, it is acceptable to merely install it on the helmet. If the camouflage cover is used, the helmet strap goes on the outside over the camouflage cover.

Five detectors provide 360 degree azimuth and ± 50 degree elevation coverage for susceptibility of the head to laser shots. Figure 4-46 shows the detector configuration common to all MILES detector assemblies. Molded plastic protective covers are installed over the glass windows of the detectors to prevent breakage. Typical detector and bare cell off-axis responses are shown in figure 4-47 from test data taken with the detector assemblies and with bare solar cells. The detector assemblies have RFI shielding and the plastic cover provides a smooth exterior surface that can easily be wiped clean. A metal grid, internal to the assembly, is used for RFI shielding. *

The helmet electronics are shown in figure 4-48. The total net weight for the helmet strap is approximately 24 ounces, including the electronics box.

Laser messages received by the detectors are amplified in the helmet electronics package and then transmitted by the loop driver electronics to an inductive loop sewn into the lower rim of the helmet strap. This loop is inductively coupled to a similar loop in the man-worn harness. Receipt of the inductively coupled message by the electronics decoder box on the man-worn harness will initiate a kill or near-miss indication, depending upon the coded message.

4.4.1.2 Harness Detector Assembly

The man-worn harness is similar to the Army's standard issue lift harness with the addition of laser detectors, decoder electronics, hit indicator, and wiring sewn into the harness (figure 4-49).

Signals received either from the inductive loop (helmet hits) or from the harness detectors (torso hits) are transmitted by wires to the decoder electronics assembly where they are amplified, decoded, and then used to actuate a signal that triggers the hit indicator. The hit indicator is an audio alarm sewn into the harness and located on the shoulder below the left ear. The alarm frequency is 2900 ± 500 Hz and its sound level is 64 to 78 dB at 12 inches distance.

The decoder, shown in figure 4-50, is located on the back of the harness between the shoulders as shown in figure 4-51. The decoder is attached by screws to the harness. Battery replacement can be performed by loosening a thumb screw and opening a battery door The battery is then lifted out and a new battery inserted by pushing it into the battery cavity and resecuring the battery door. The weapon key

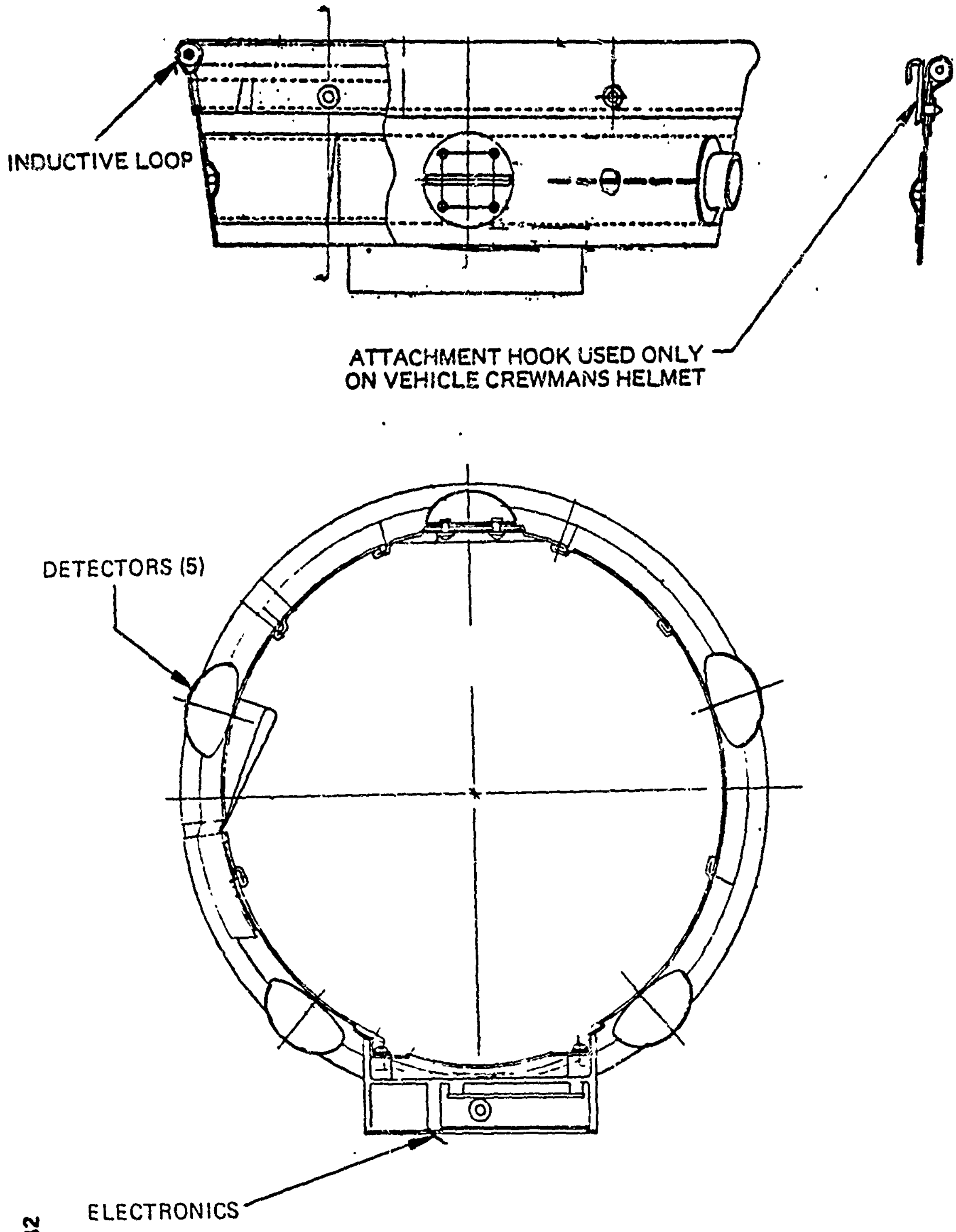

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Figure 4-45. Harness Assembly, Helmet

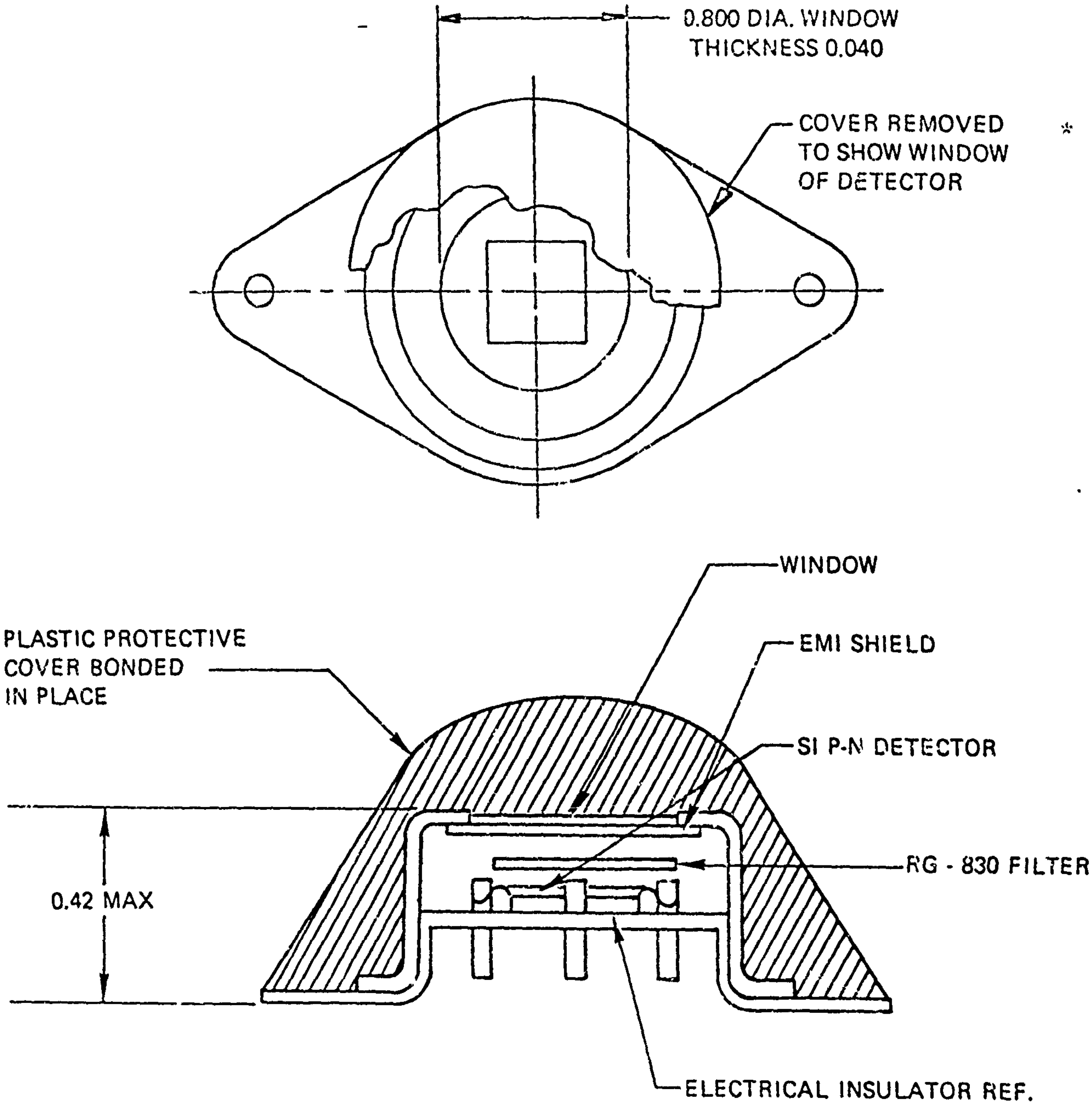

Figure 4-46. Detector Configuration

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57286

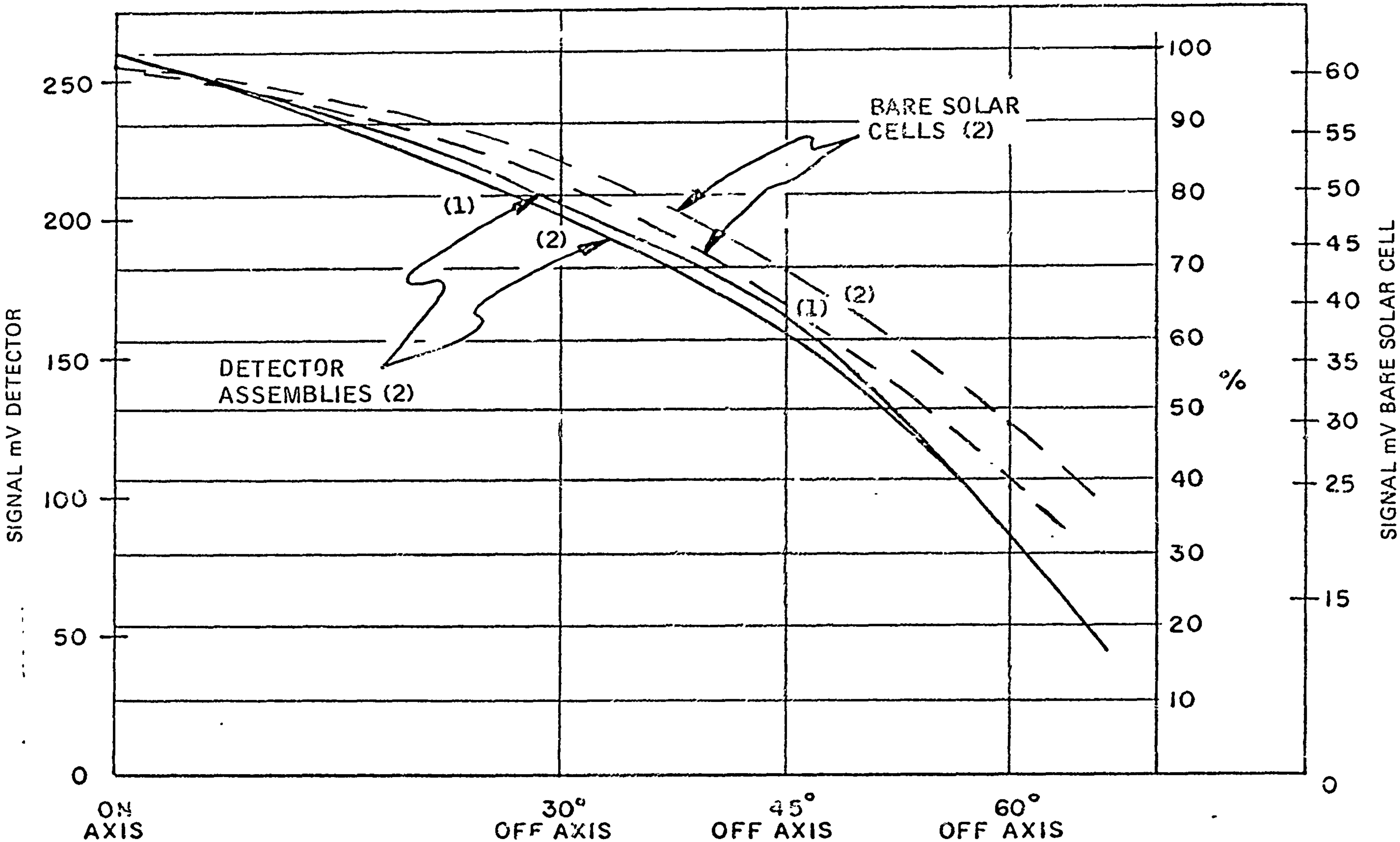

Figure 4-47. Detector Off-Axis Response

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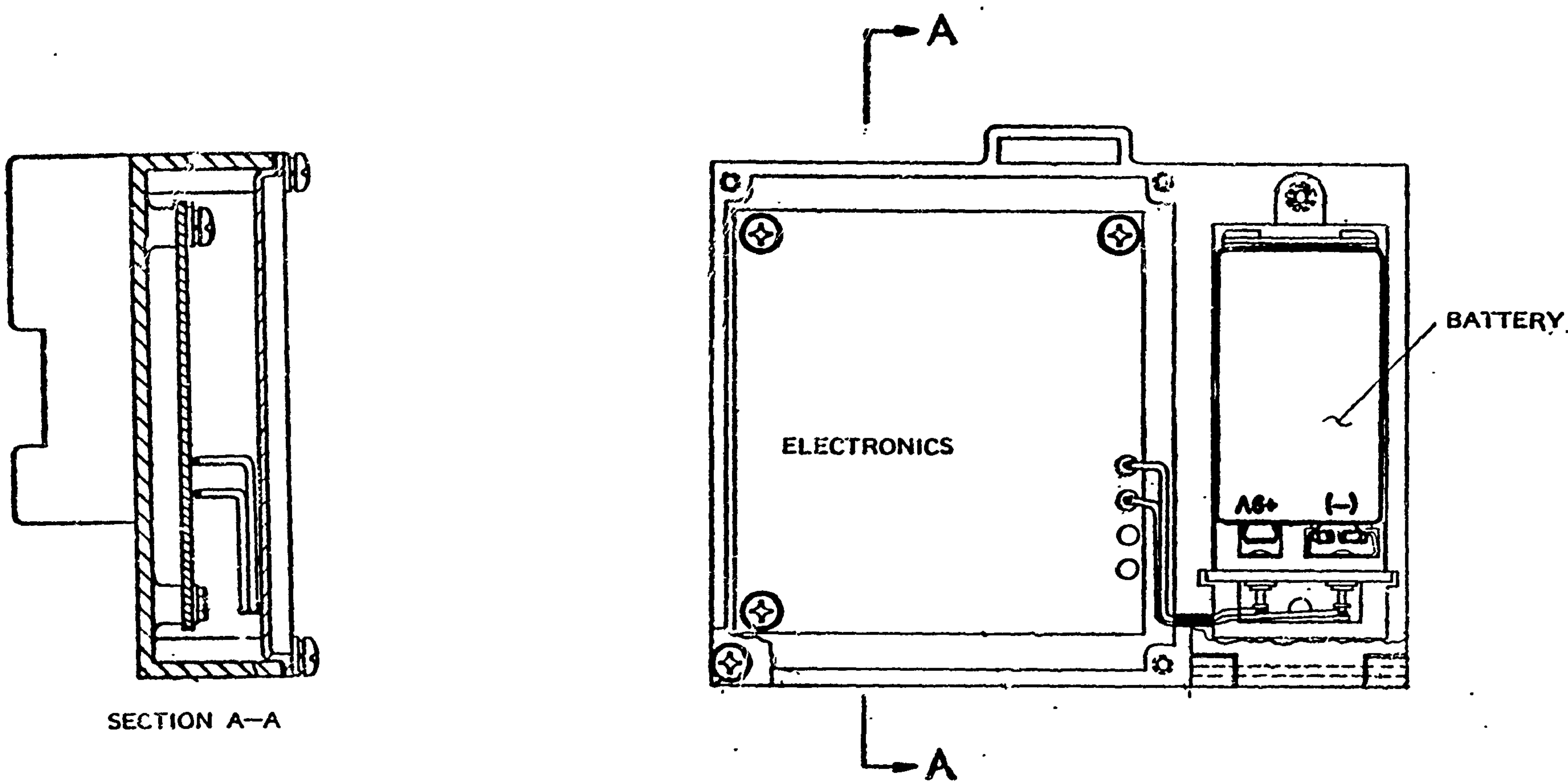

Figure 4-48. *MWLD* Helmet Electronics Assembly

65686

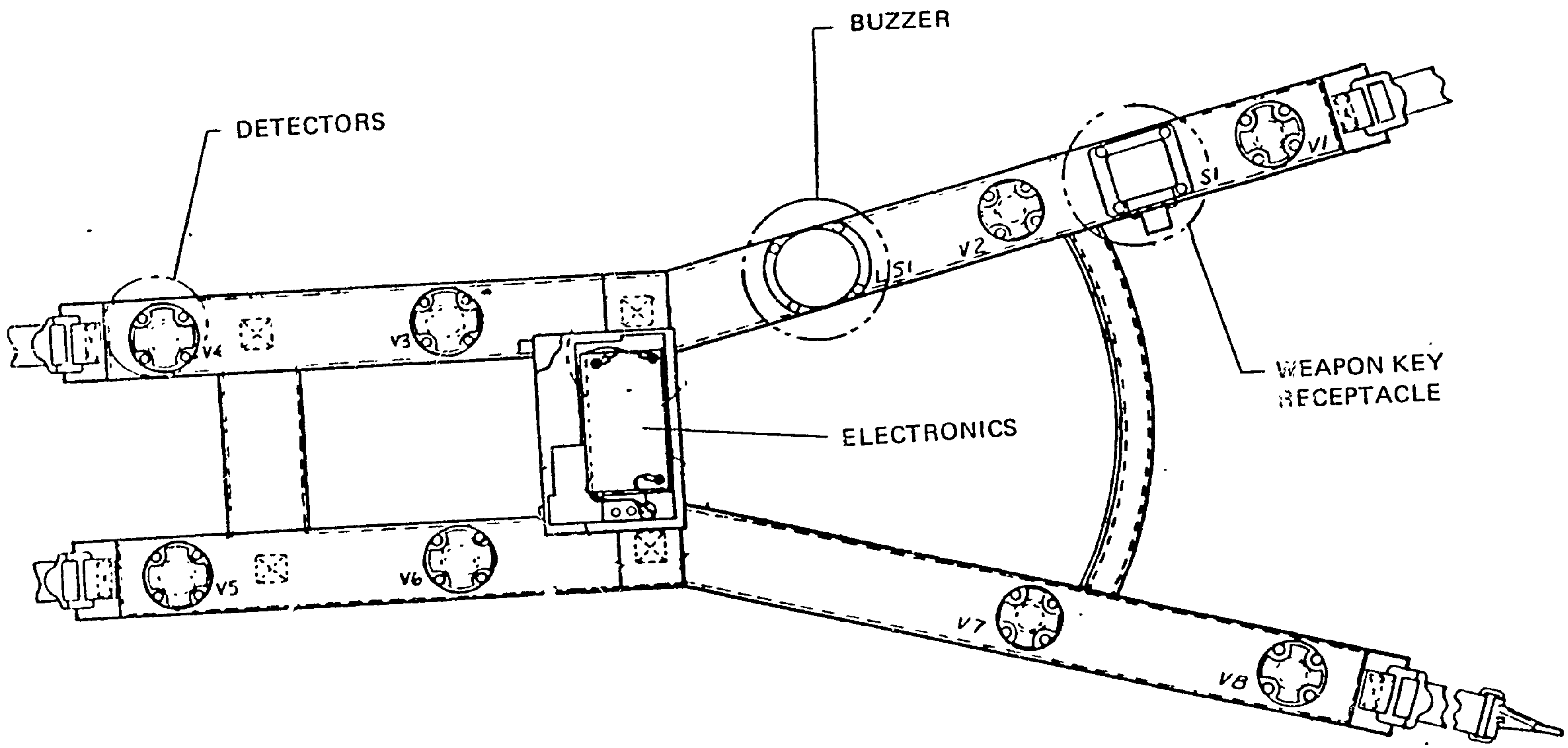

Figure 4-49. MWLD - Torso Harness Assembly

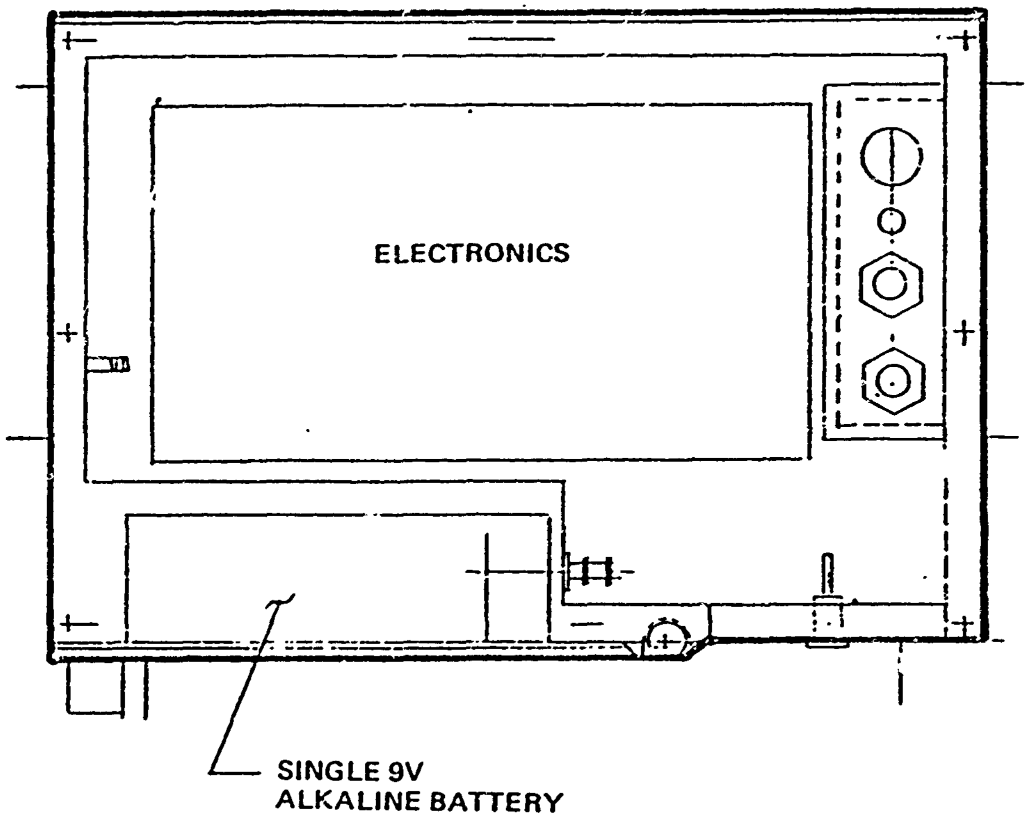

Figure 4-50. MWLD Torso Electronics Assembly

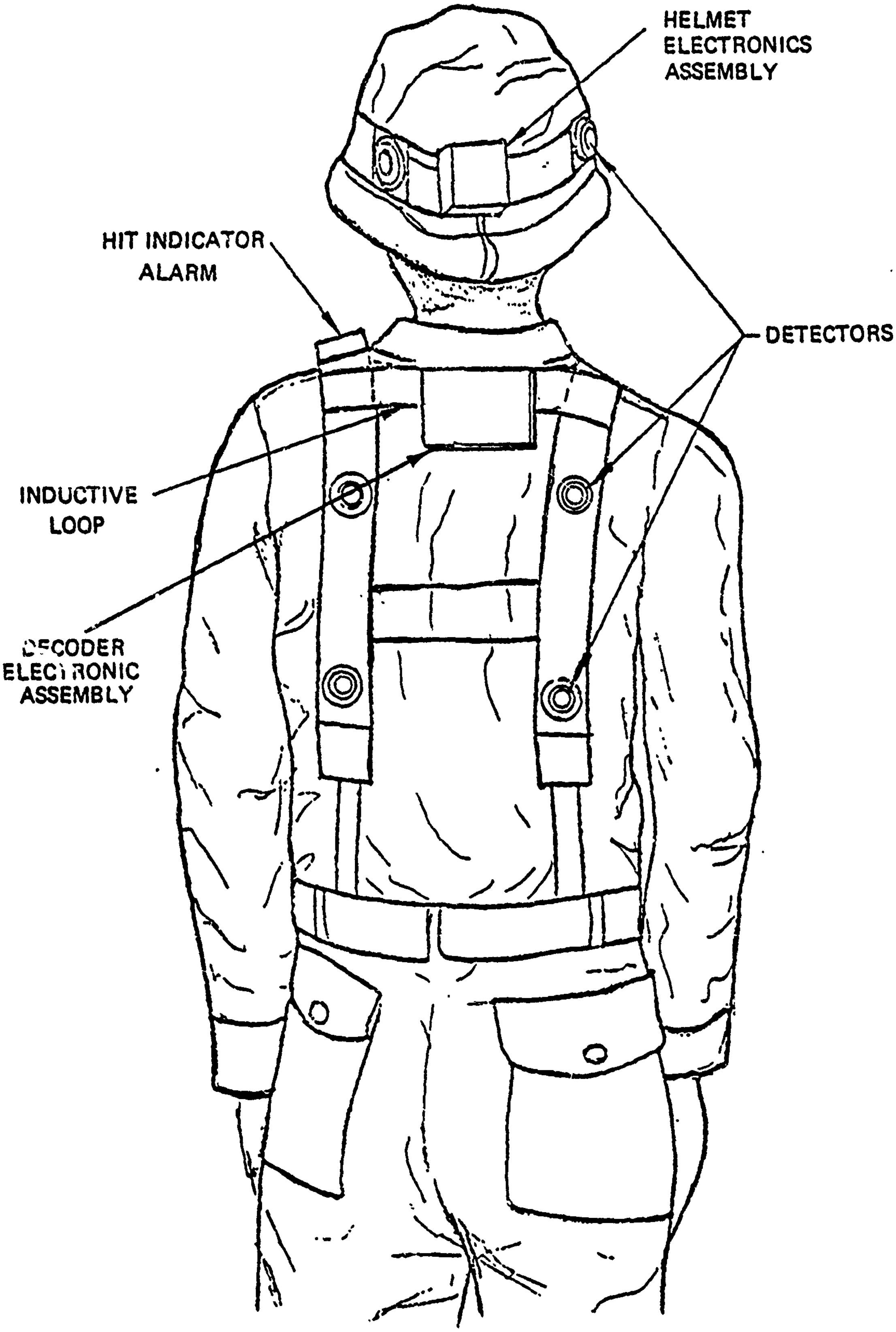

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Figure 4-51. MWLD Harness, Rear View

receptacle is located on the front left strap between the two detectors as shown in figure 4-52. This allows ready access for insertion of the yellow weapon key to shut down the alarm.

The harness is constructed from heavy nylon webbing. A light nylon web is sewn onto the basic harness to form a wire raceway. The detectors are soldered to the wire leads and riveted to the harness. The inductive loop is sewn into the harness around the neck. Two turns of the inductive loop are completed by the strap across the chest. *

4.4.1.3 Safety

The hit indicator, shown in figures 4-51 and 4-52 is located approx 6 inches from the soldiers left ear. At that distance, the sound pressure from the alarm is approximately 92 dB which is above the safety limit for continuous noise. It is important therefore, that the infantryman turn off his alarm when a "kill" occurs. Figure 4-53 is a sound pressure map of the MWLD alarm.

4.4.2 COMBAT VEHICLE LASER DETECTOR (CVLD)

The CVLD is a common name for the elements that make up a vehicle detection system. The CVLD is similar in function to the MWLD described in subsection 4.4.1 but has added capabilities and complexity. The elements which comprise the CVLD are:

a. Detector Belt Segment Assemblies

b. Decoder Assemblies

- Control Indicator Assembly (CIA) - Used only on the M113 APC Systems
- Loaders Control Indicator (LCA) - Used on all other vehicle systems

c. Combat Vehicle Kill Indicator (CVKI) Assembly

These modules are connected by cable assemblies which are a part of the vehicle adapter kits discussed in subsection 4.5.

4.4.2.1 Detector Belt Assembly Segments

The Detector Belt Assembly segments, shown in figure 4-54, are designed for use in various combinations to make up detector belt sets for each of the vehicles in the MILES system. Each belt contains SiPn detector modules and an electronic threshold/detector preamplifier module. The detector modules are common throughout the MILES system. GaAs laser signals received by the detector modules are amplified and then routed to the vehicle decoder assembly by means of wiring sewn into the belt segments. The belt segments have fastener tape (pile-type) backing and attach to vehicles which have the mating hook-type fastener tape.

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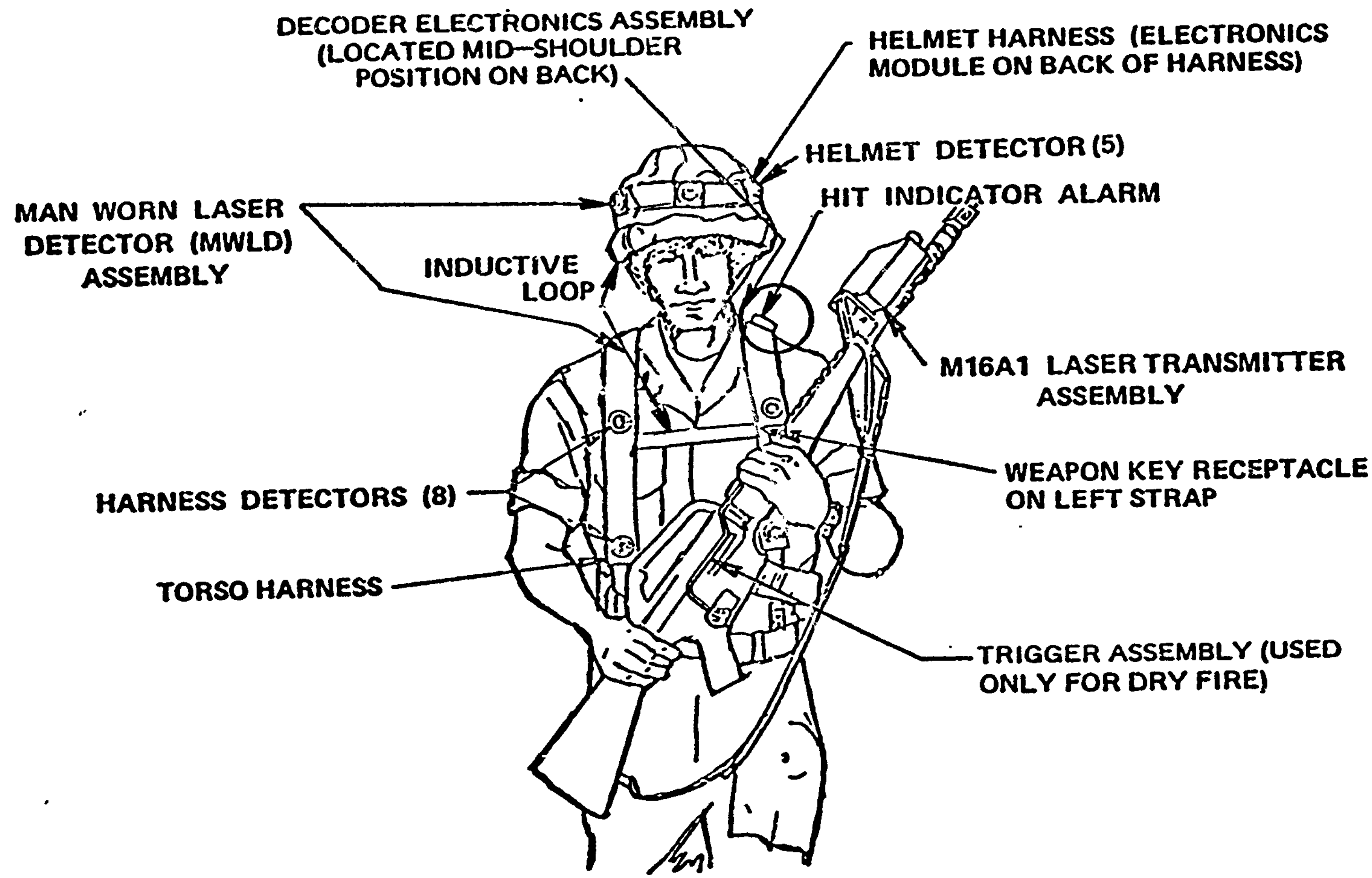
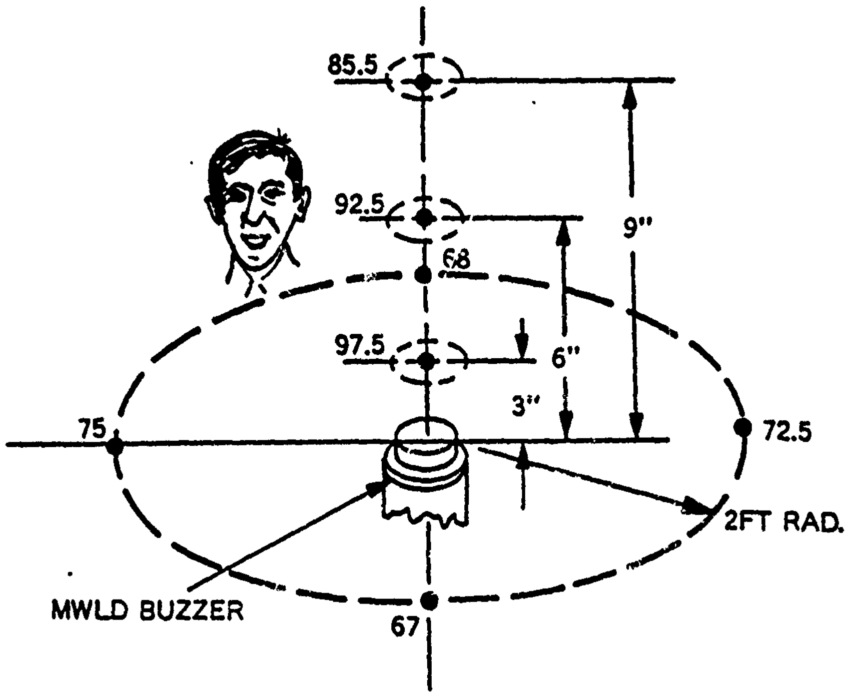


Figure 4-52. MWLD Harness Front View



AT 12" IN ANY DIRECTION FROM THE ALARM
THE PRESSURE LEVEL IS LESS THAN 85 db

61067

Figure 4-53. MWLD Alarm, Sound Pressure (dB) Map

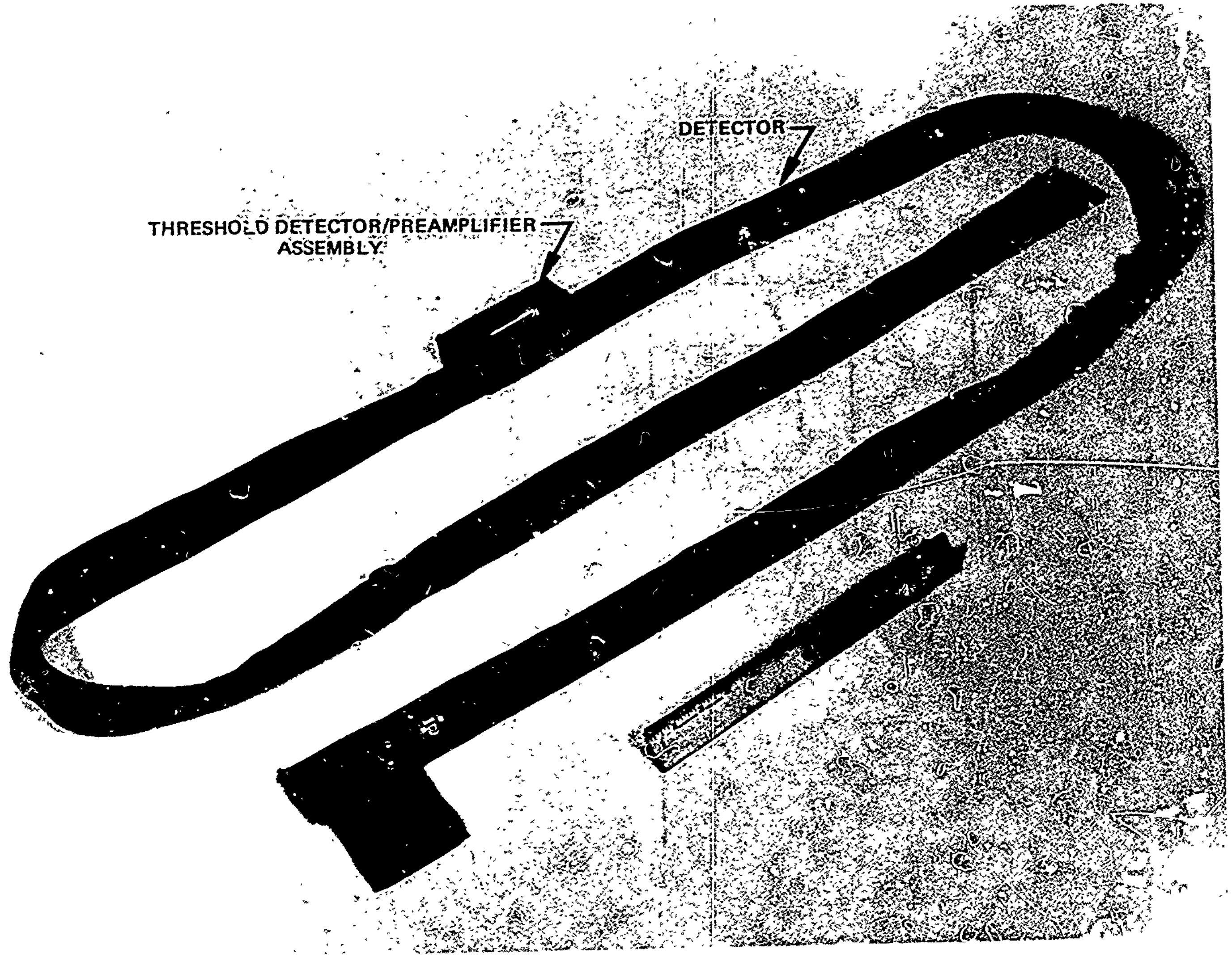


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Figure 4-54. Detector Belt Assembly Segment

Five different belt segment configurations in various combinations are used to make the vehicle belt sets as follows:

M113 APC	Length (in.)	No. of Detectors
• Belt Segment No. 1 (2 each)	167	6
• Belt Segment No. 2 (2 each)	83	4
M60A1/A3 Tank		
• Belt Segment No. 3 (2 each)	175	8
• Belt Segment No. 4 (1 each)	149	6
M60A2 Tank		
• Belt Segment No. 3 (2 each)	175	8
• Belt Segment No. 5 (1 each)	216	7
M551 AARV		
• Belt Segment No. 3 (2 each)	175	8
• Belt Segment No. 4 (1 each)	149	6

*

The belt segments differ primarily in length, detector quantity, and detector placement. The belts are constructed of heavy olive drab colored nylon webbing. Wiring is sewn into the belt segments. The segments are joined electrically by in-line connectors and mechanically by Velcro fastener tape. For sloping turrets, Velcro covered wedges (see figure 4-55), a part of the vehicle adapter kits, return the detectors to a plane parallel with the horizontal.

Interconnecting cabling, a part of the adapter kit, completes the hookup of the detection belts to the decoder assembly inside the vehicle.

4.4.2.2 Decoders (LCA and CIA)

The Loader's Control Assembly (LCA), shown in figure 4-56, is used on all vehicles in the MILES except on the M113 APC where a similar unit, the Control Indicator Assembly (CIA), shown in figure 4-57, is substituted. The basic difference is that the CIA does not perform the function of firing dependent laser transmitters, and therefore does not have "ROUNDS REMAINING" positions on the front panel selector switch, nor does it perform an encoding function.

Figure 4-58 is a block diagram of the typical vehicle system showing the interrelationship of the LCA to the other assemblies within the system. This diagram applies to the CIA as well if the "Dependent Transmitter" block is removed.

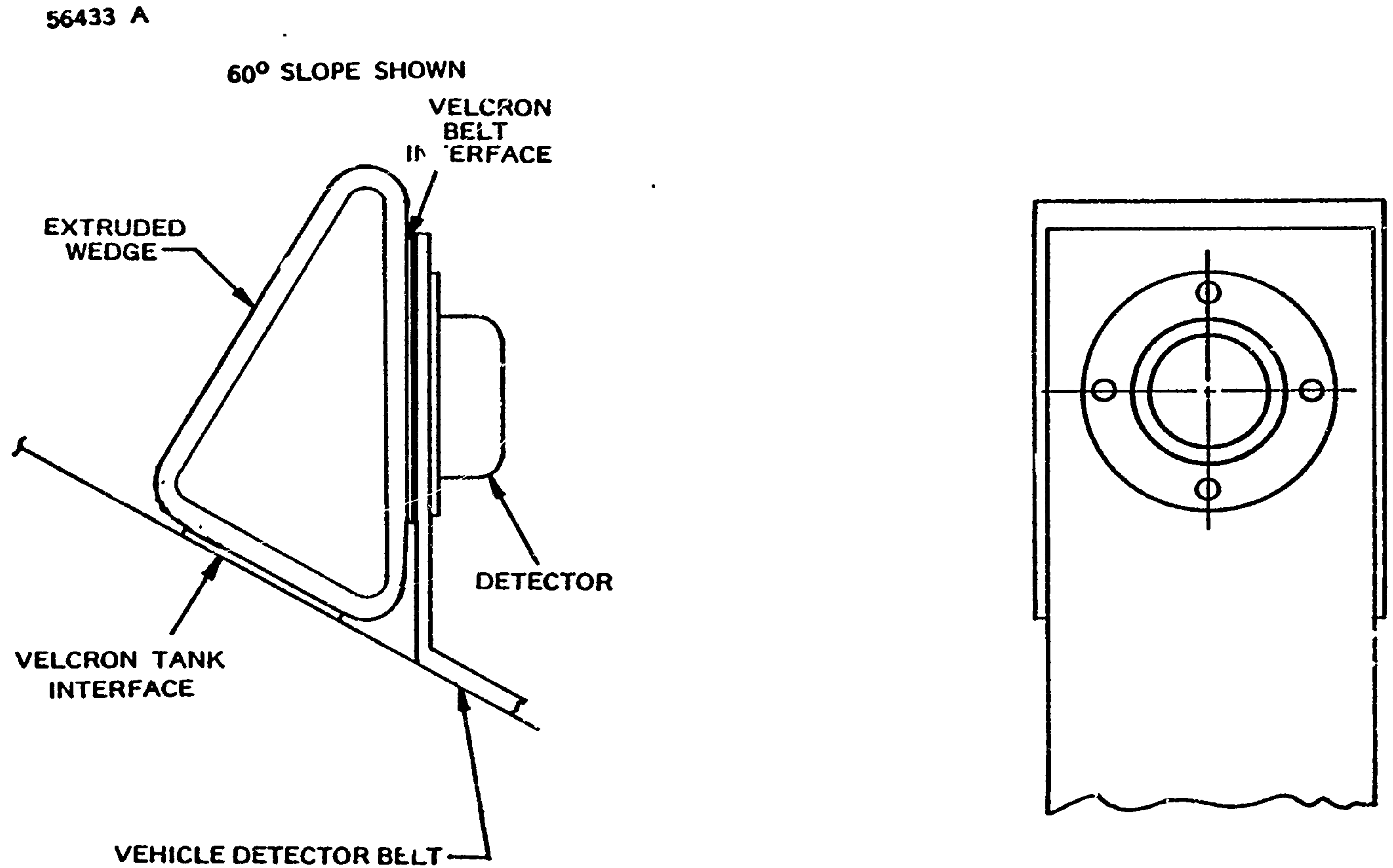

Figure 4-55. Wedge with Belt

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Figure 4-56. Control Console (LCA)

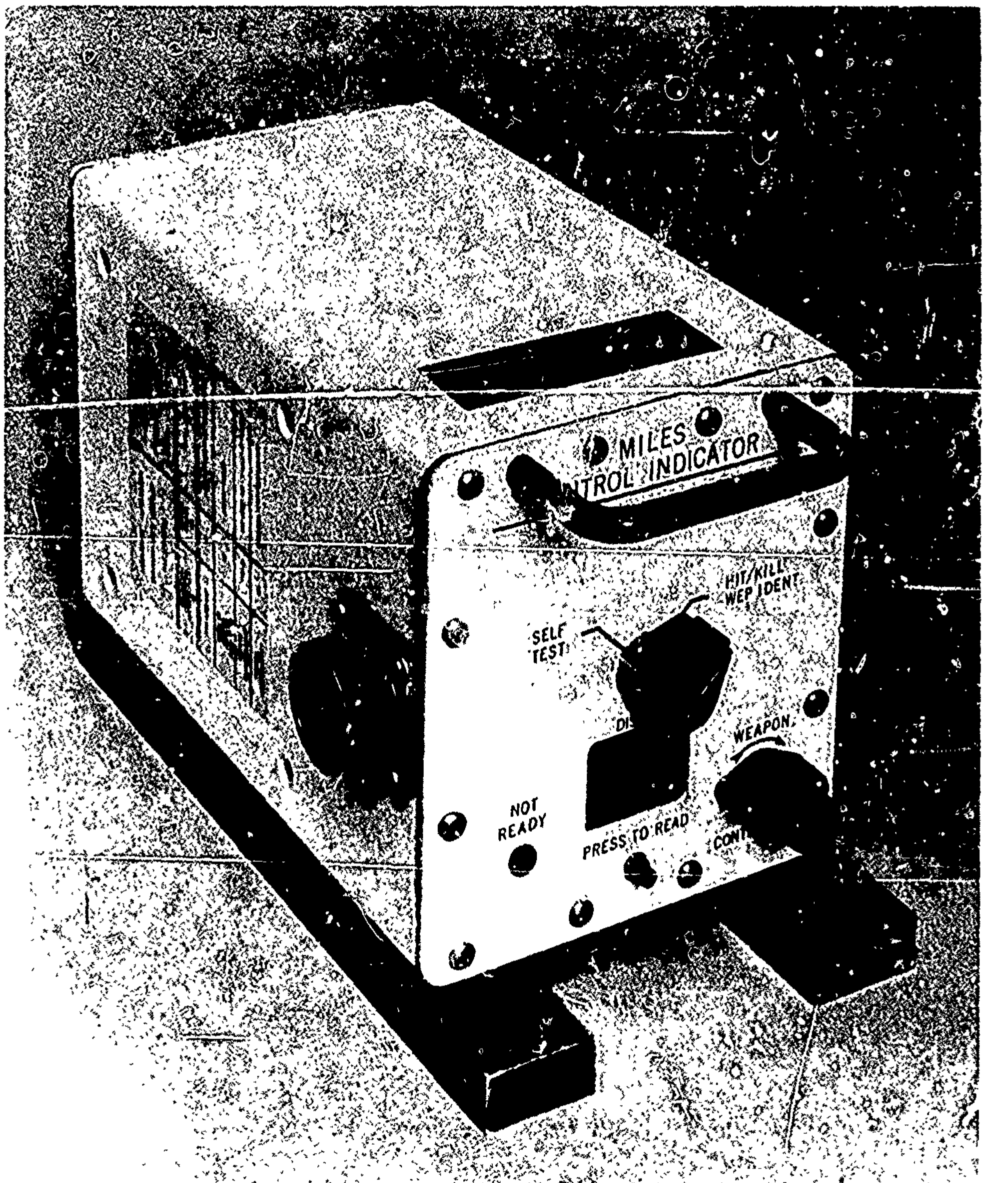

Figure 4-57. Control Indicator (CIA)

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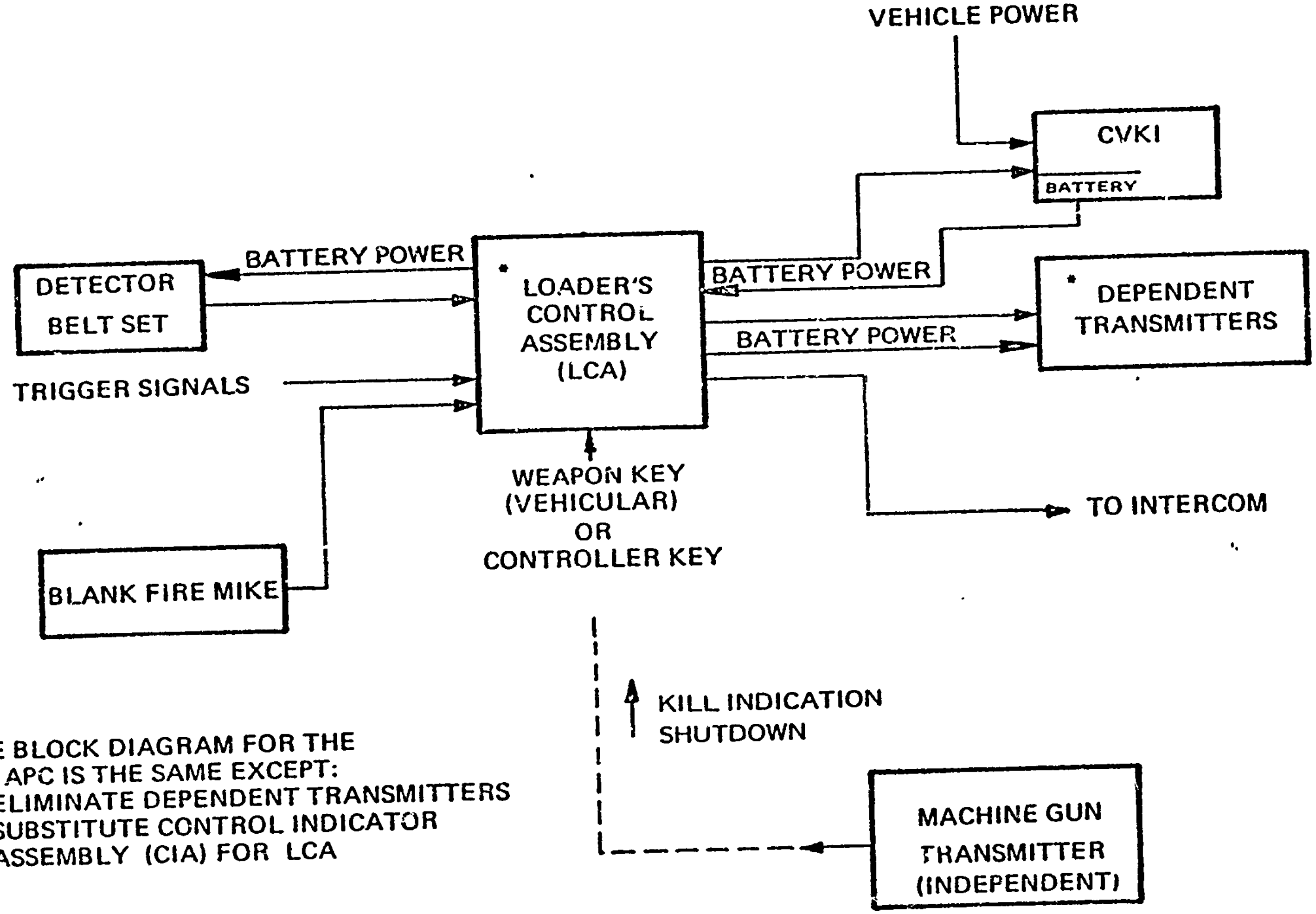


* THE BLOCK DIAGRAM FOR THE M113 APC IS THE SAME EXCEPT:
- ELIMINATE DEPENDENT TRANSMITTERS
- SUBSTITUTE CONTROL INDICATOR ASSEMBLY (CIA) FOR LCA

Figure 4-58. Vehicle Systems - General Block Diagram

Power for the vehicle system is supplied from batteries located in a battery box. This battery power is supplied to the LCA/CIA. The LCA then supplies power to the dependent laser transmitters and to the detector belt set. The CIA supplies power only to the detector belt set.

ENCODING

When firing the vehicle weapon simulators, the actual weapon triggers are used, and firing signals are routed to the LCA. The LCA takes these firing signals and uses them to trigger and fire the dependent laser transmitters. The laser transmission is encoded within the LCA for its weapon identification. Figure 4-59 is a block diagram showing the dependent laser transmitter functions and the interface with the LCA. The dependent laser transmitters for ED MILES are:

a. M60A1/A3 TANKS

- 105 mm/Coax Laser Transmitter Assembly

b. M60A2 TANK AND M551 AARV

- 152 mm/Coax/SHILLELAGH Laser Transmitter Assembly

The coax machine gun, when used in the blank fire mode, is monitored by a microphone assembly. Output of the microphone is routed to the LCA where it is used to trigger the coax machine gun transmitter.

DECODING

Incoming laser signals are received by the detector belt set, amplified, and routed to the LCA or CIA where they are decoded. Signals are evaluated to be:

- Nonsense code - no response
- Valid Hit
- Valid Kill
- Valid Near Miss

CONTROL FUNCTIONS OF LCA/CIA

After decoding, a signal is used to activate the CVKI, intercom, and where applicable, the NOT READY light on the panel of the LCA/CIA. When the incoming signal results in a valid kill, the LCA automatically deactivates all dependent laser transmitters.

The target vehicle responses to near miss, hit and kill are detailed in figures 4-60 through 4-62 for both the LCA and the CIA, with the front panels of these assemblies shown for easy reference.

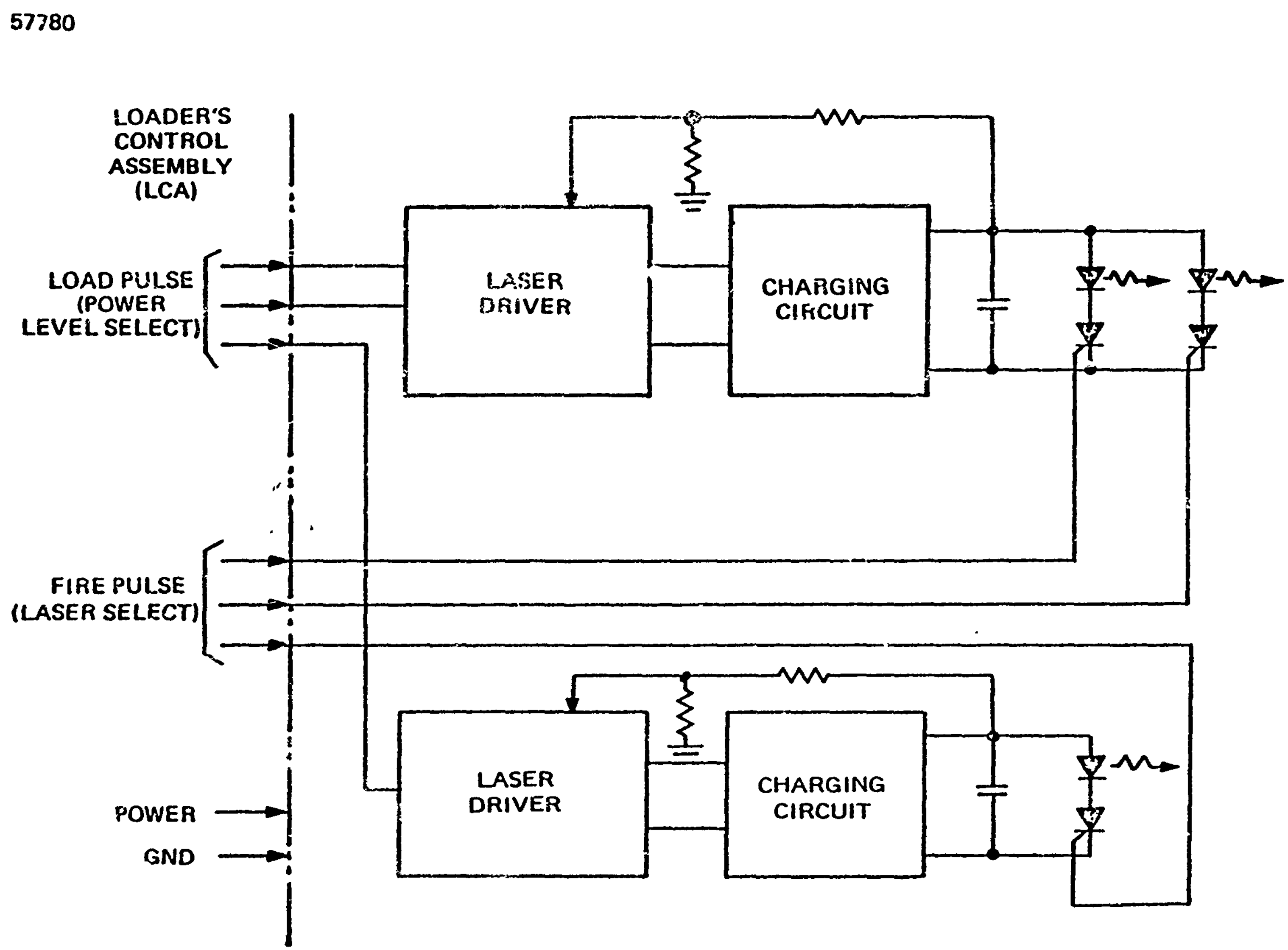
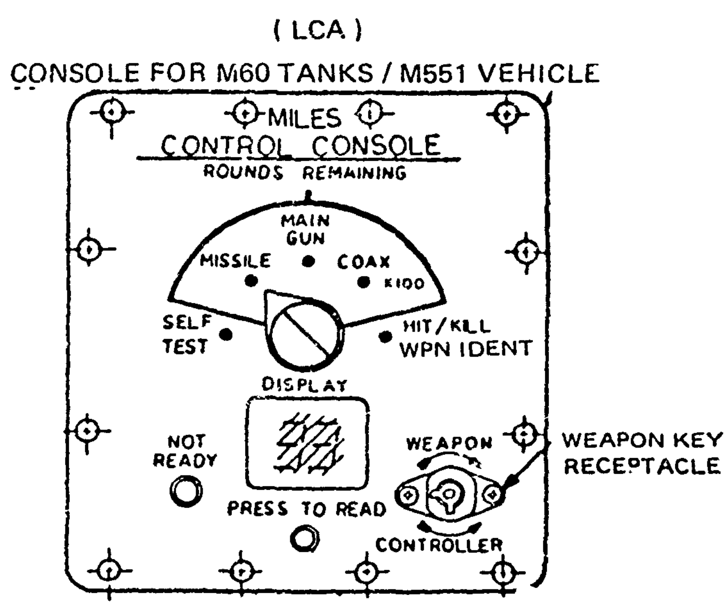


Figure 4-59. MILES Dependent Laser Transmitter Functional Block Diagram

57678

- CVKI — TWO FLASHES
- INTERCOM — TWO TONES
- NOT-READY (TO FIRE) INDICATOR — NO RESPONSE
- HIT / KILL INDICATOR — NO CHANGE
- FIRING CAPABILITY — NO EFFECT
- IN-PROCESS TRACKING — NO EFFECT



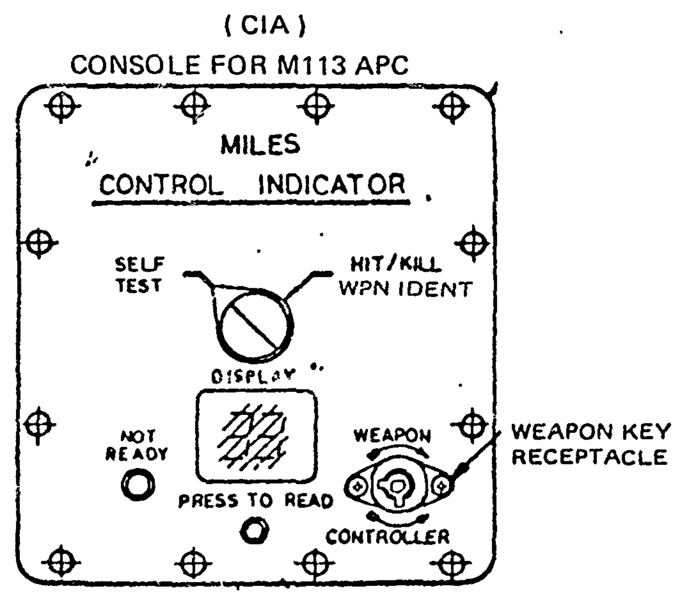
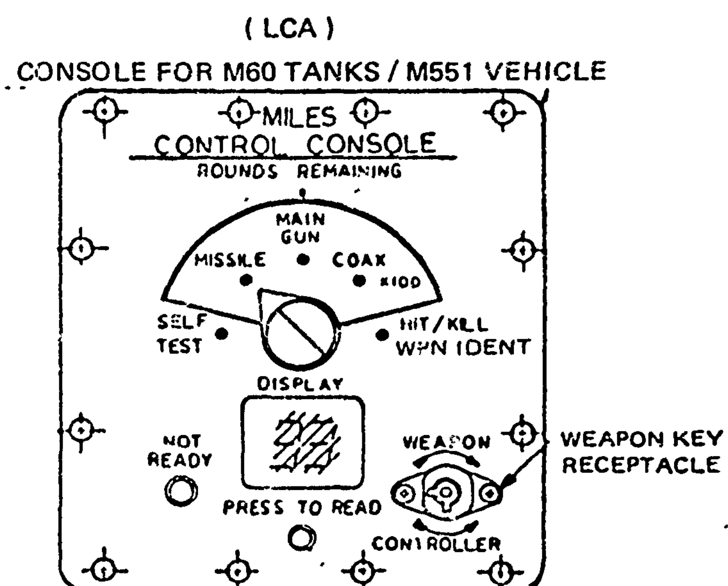


Figure 4-60. Target Vehicle Near-Miss Response

57600

- CVKI — FOUR FLASHES
- INTERCOM — FOUR TONES
- NOT–READY (TO FIRE) INDICATOR — NO RESPONSE
- HIT / KILL WEAPON IDENT. — DISPLAYS CODE NO. OF ATTACKING WEAPON WHEN PRESS–TO–READ BUTTON IS DEPRESSED
- FIRING CAPABILITY — NO EFFECT
- IN–PROCESS TRACKING — NO EFFECT



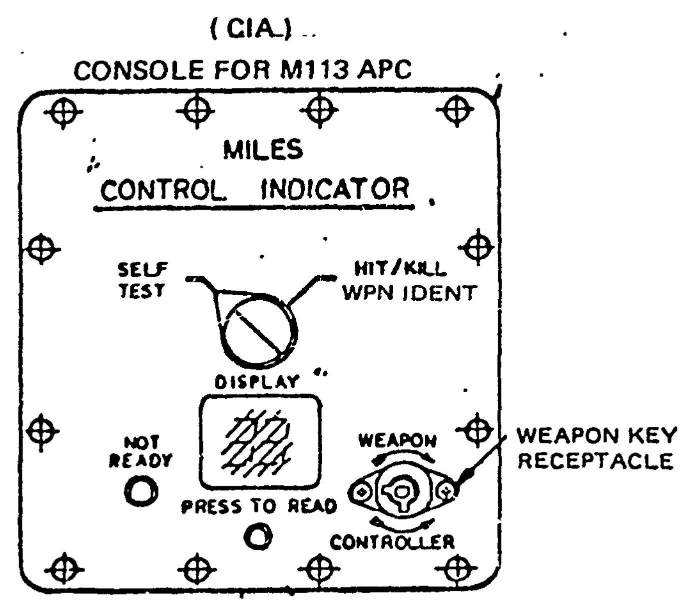


Figure 4–61. Target Vehicle Hit Response

57681

- CVKI — CONTINUOUS FLASHING UNTIL RESET BY CONTROLLER
- INTERCOM — CONTINUOUS TONE UNTIL DISABLED BY CUPOLA GUN WEAPON KEY IN WEAPON KEY RECEPTACLE
- NOT–READY (TO FIRE) INDICATOR — CONTINUOUSLY ILLUMINATED UNTIL DISABLED BY CUPOLA GUN WEAPON KEY IN WEAPON KEY RECEPTACLE.
- HIT / KILL WEP IDENT — DISPLAYS CODE NUMBER OF ATTACKING WEAPON WHEN PRESS–TO–READ BUTTON IS DEPRESSED.
- FIRING CAPABILITY — MAIN GUN MISSILE AND COAX AUTOMATICALLY DISABLED; CUPOLA GUN DISABLED BY REMOVAL OF WEAPON KEY.
- IN–PROCESS TRACKING — ABORTED INSTANTLY.

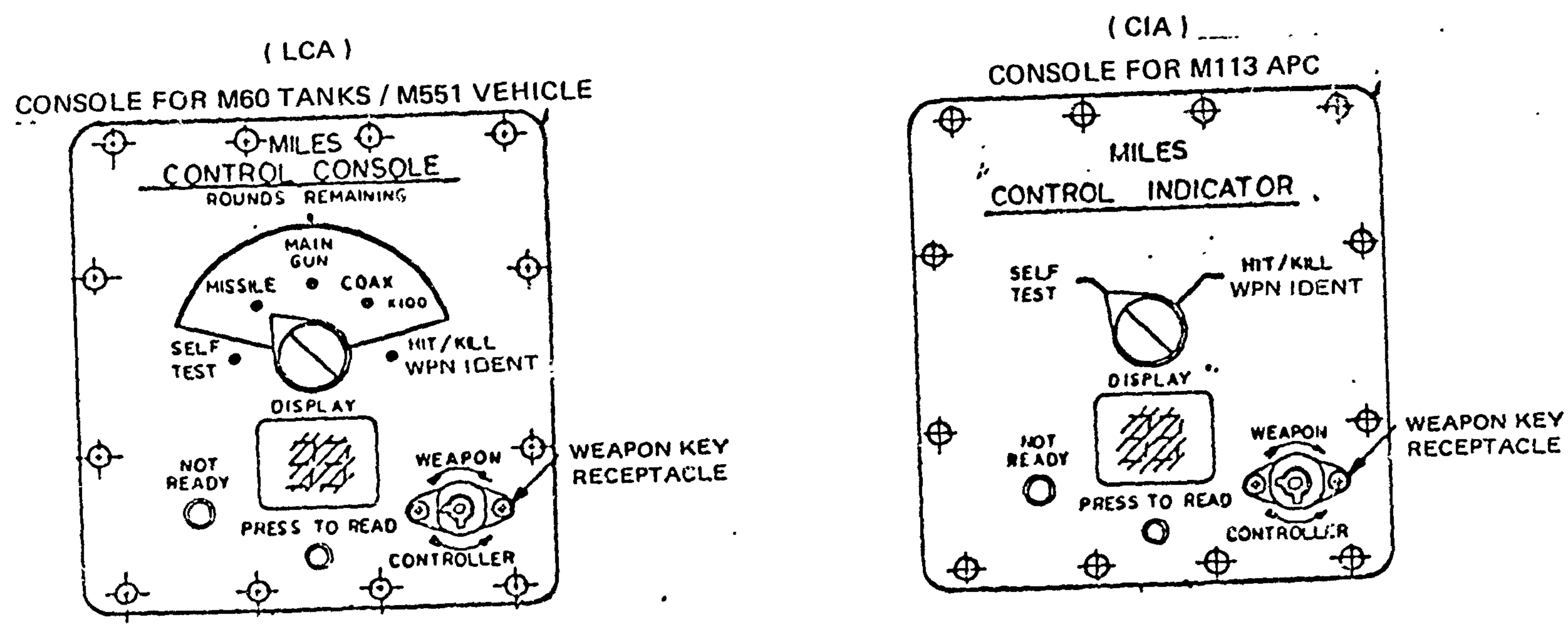


Figure 4–62. Target Vehicle Kill Response

When the vehicle is killed, the CVKI strobe light is activated and operates continuously. A continuous tone is also inserted into the vehicles intercom system. This noise can only be shut down by removing the weapon key from the cupola gun independent transmitter and by inserting it in the weapon key receptacle of the LCA/CIA to turn off the alarm. The independent transmitters are:

a. M113 APC

- M2 Machine Gun

b. M60A1/A3 TANK

- M85 Machine Gun

c. M60A2 TANK

- M85 Machine Gun

d. M551 AARV

- M2 Machine Gun

DISPLAYS

a. Casualty Assessment

After-action casualty assessment can be performed using the LCA/CIA. By rotating the selector switch to "HIT/KILL WEP IDENT" and pressing the "PRESS TO READ" button, a number is read out on the "DISPLAY." This is the identification number of the last weapon to hit or kill the vehicle. A Casualty Assessment card is supplied to the vehicle crew (see figure 4-63). This card cross-references weapons to their identification numbers.

b. Rounds Remaining

The initial basic load of ammunition for the vehicle dependent laser transmitters is set at the time the controller enables the system by use of his Controller Key in the weapon key receptacle of the LCA. Basic ammunition loads are fixed and are:

a. M60A1/A3 TANK

- 105 mm Main Gun - 63 rounds
- Coax Machine Gun - 1800 rounds

CASUALTY ASSESSMENT

HIT/KILL WEAPON CODE NO.	ATTACKING WEAPONS
00	Controller Gun
01	Maverick
02	TOW, Shillelagh†
03	Dragon†
04	Viper†
05	152mm†
06	105mm†
07	TOW, Shillelagh, Sagger, Helfire [ASH]
08	Dragon
09	M202 Flame
10	M21 Antitank
11	Claymore M81A1 and M16
12	105mm
13	152mm, 155mm, 8 inch Rocker, 105 Howitzer
14	2.75 inch Rocker
15	Viper
16	120mm
17	90mm
18	75mm and 73mm [Russian APC]
19	Grenade [40mm]
20	Rockeye [Cluster Bomb]
21	GAU-8, AH [30mm]
22	Bushmaster [25mm], ZU23-4 [23mm]
23	Vulcan [20mm[]
24	M2, M85 Machine Gun
25	Roland II, Chaparral
26	Stinger
27	M16 Rifle, M60 MG, Coax Mg

† Special 100% Kill Codes

Figure 4-63. Casualty Assessment Card

b. M60A2 TANK

- 152 mm Main Gun - 33 rounds
- Coax Machine Gun - 1800 rounds
- SHILLELAGH Missile - 13 rounds

c. M551 AARV

- 152 mm Main gun - 20 rounds
- Coax Machine Gun - 1800 rounds
- SHILLELAGH Missile - 9 rounds

The rounds remaining are checked by rotating the selector switch to "ROUNDS REMAINING" and the weapon in question. By pressing the "PRESS TO READ" button, the rounds remaining indication is then read out on the "DISPLAY." A "00" display indicates all rounds have been expended.

c. <u>Other Switch and Display Functions</u>

Figures 4-64 and 4-65 depict decals that are applied to the housings of the LCA and CIA. These decals list the switch positions, the possible display readings, and the meaning of the numbers that appear on the display for the various switch positions.

4.4.2.3 <u>Battery Box</u>

The battery box, shown in figure 4-66, houses two 6-volt lantern-type batteries. These batteries are used to power the following dependent transmitters:

a. M60A1/A3 Tank

- 105mm Main Gun
- Coax Machine Gun

b. M60A2 Tank

- 152mm Main Gun
- Coax Machine Gun
- Shillelagh Missile

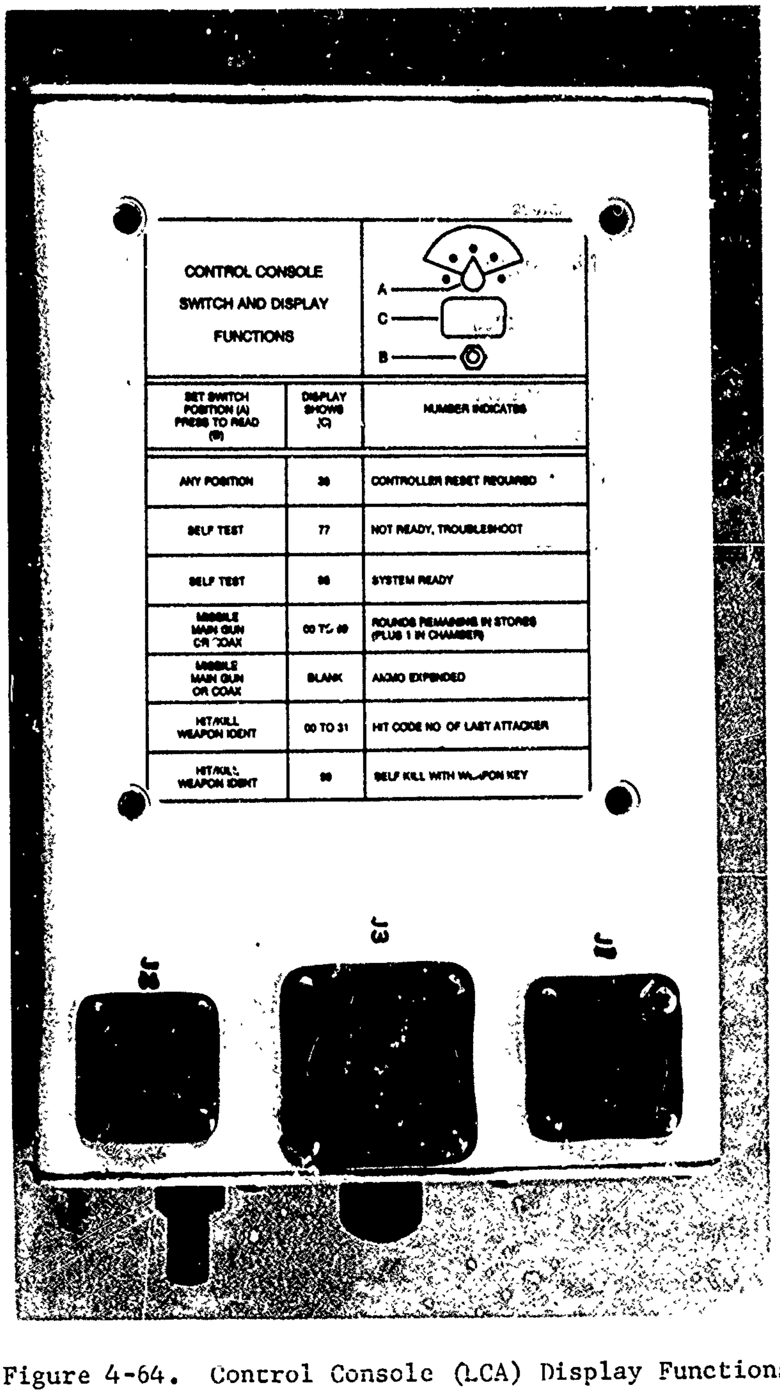


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Figure 4-64. Control Console (LCA) Display Functions

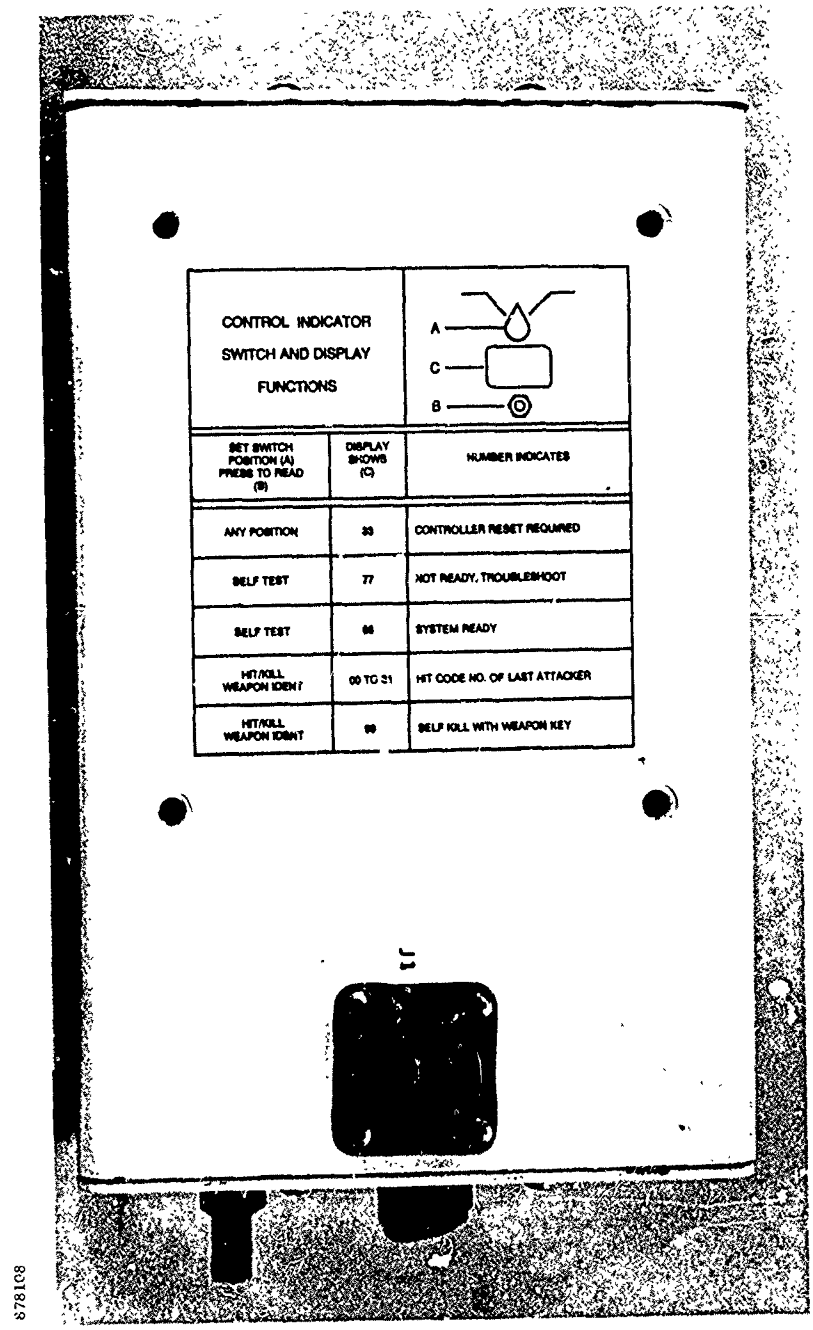
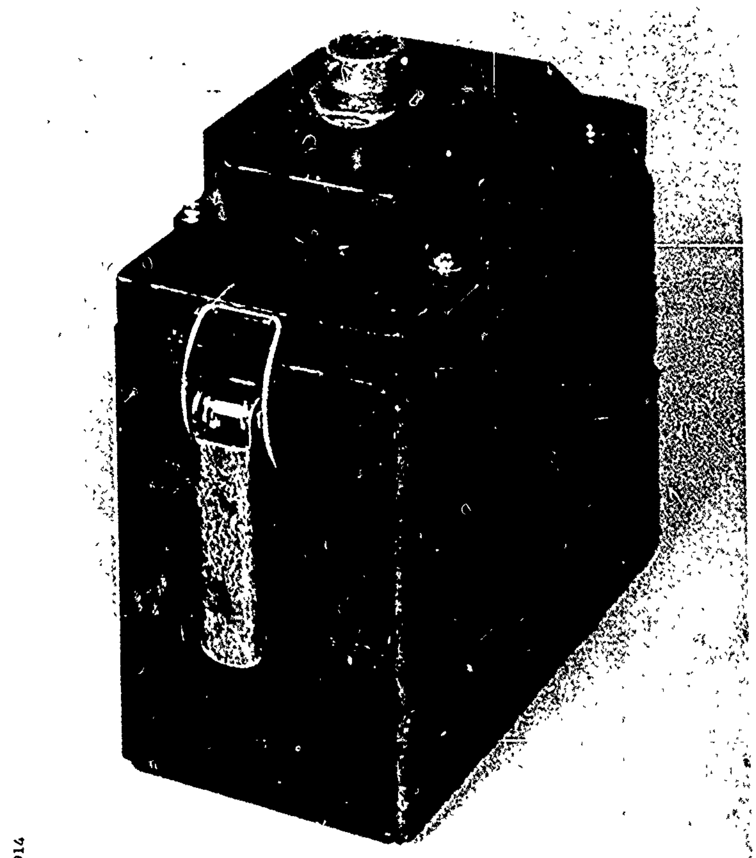


Figure 4-65. Control Indicator (CIA) Display Functions



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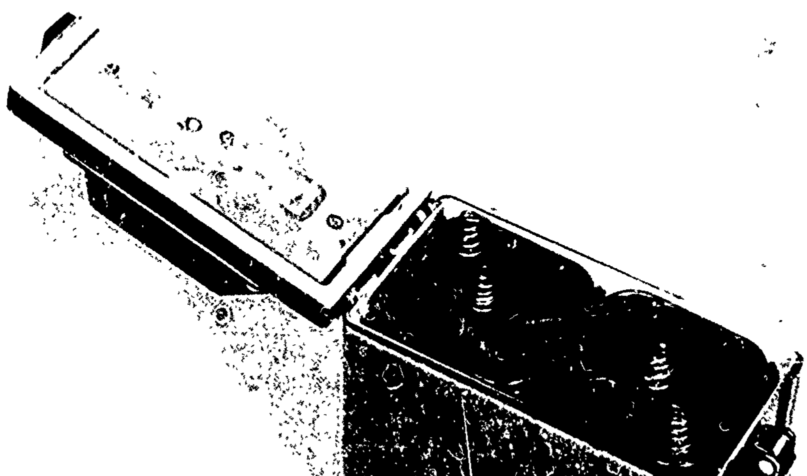
(a) Cover Closed and Locked



97913

(b) Cover Open

Figure 4-66. Battery Box

c. M551 AARV

- 152mm Main Gun
- Coax Machine Gun
- Shillelagh Missile

The batteries also provide power for operating the LCA and CIA and the vehicle detector belt electronics.

The battery box is located inside the vehicles and is connected to the LCA or CIA by the battery cable. The box is secured to the vehicle by mounting with a Velcro pad. The batteries are inserted into the box with their power clips out so that they contact the printed circuit board which is installed in the battery box door. Battery power is applied when the battery box door is closed.

4.4.2.4 Combat Vehicle Kill Indicator Description and Function

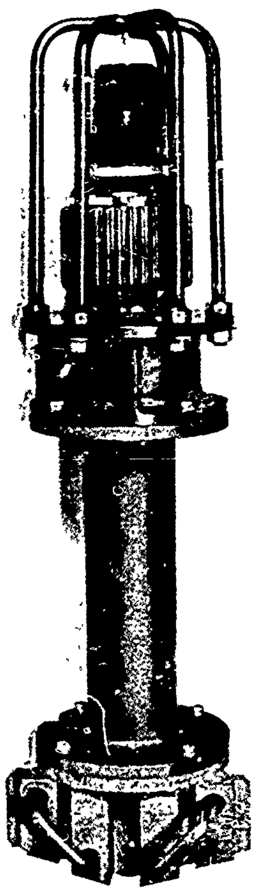
The Combat Vehicle Kill Indicator (CVKI) is a strobe light that mounts on the outside of MILES-equipped vehicles. The CVKI bolts to various pedestals depending on which vehicle the CVKI is to be installed. Figures 4-67a and 4-67b show the CVKI mounted on an M113 APC pedestal and on an M60A1/A3 tank pedestal, respectively. The pedestals are of various heights in order to raise the CVKI above portions of the vehicles which may interfere with ground troops' ability to observe the CVKI strobe light from every angle. The pedestals are designed to be mounted to one of the lifting eyes on the vehicles.

The electronics for operating the CVKI is contained in the base of the light. Power to the CVKI is supplied by a cable which attaches to a connector also at the base. Figure 4-67b shows the connector at the rear of the CVKI. The power for operating the CVKI is not dependent on the MILES batteries, but is supplied by the vehicle's 24 vdc battery supply. This arrangement is used because if the MILES batteries were used, the electrical load on the strobe light would limit the total hours of the MILES batteries to less than the specified 100 hours per field exericse.

4.5 ADAPTER KITS

The adapter kits for vehicle systems consist of the necessary cabling to interconnect the laser transmitters, CVKI, belt set, control console and vehicle triggers (see figures 4-68 and 4-69). The interconnecting cabling also interfaces with the GFE Hoffman device and picks up 24Vdc vehicle power for use with the CVKI. A breech interlock connector plug is provided to allow use of the SHILLELAGH and main gun triggers when the breech is open. Mechanical locking mechanisms are provided to assure that the tank main gun breech is positively locked in the open position.

Wedge blocks are supplied for use with the belt sets. The wedge blocks are used under the detectors on belts to return the detectors to a position normal to the horizontal when the belts are on sloping turrets.



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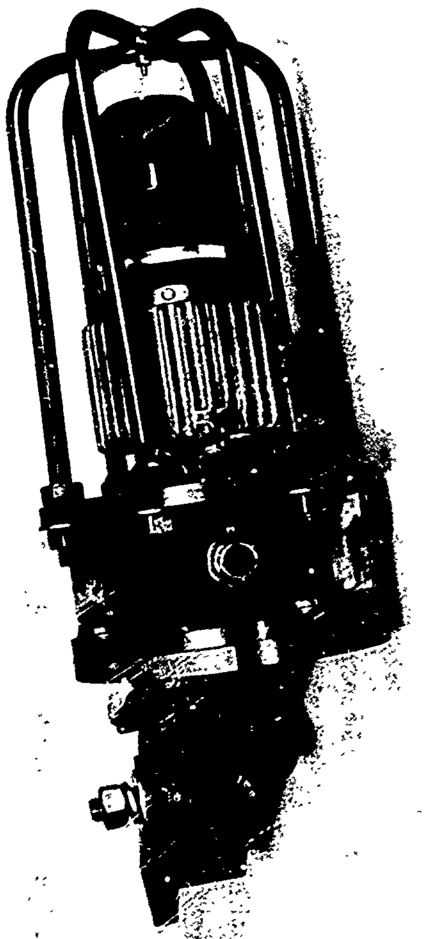
(a) CVKI Mounted on M60A1/A3 Pedestal



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(b) CVKI Mounted on M113 APC Pedestal

Figure 4-67. Combat Vehicle Kill Indicator

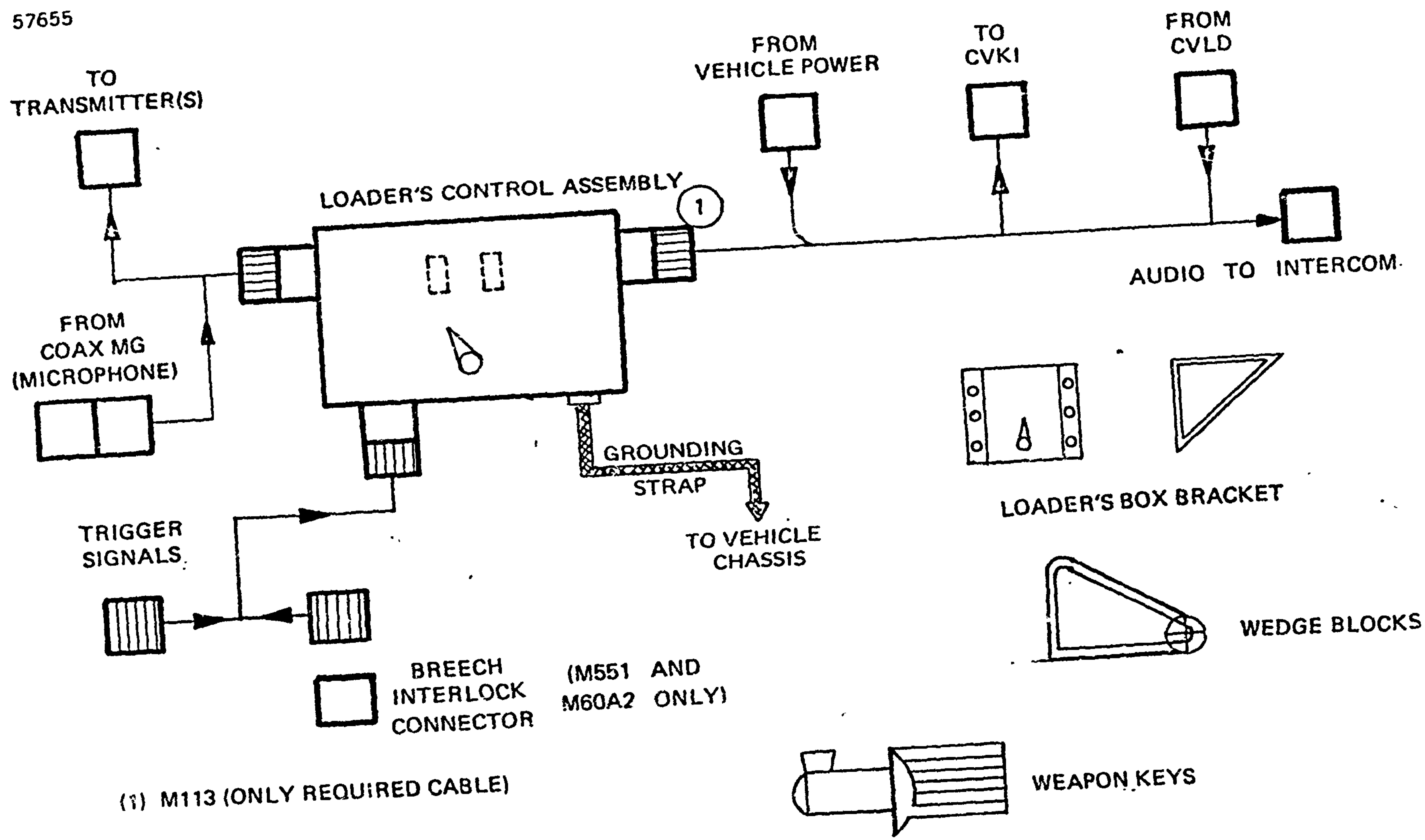


Figure 4-68. Vehicle Adapter Kits

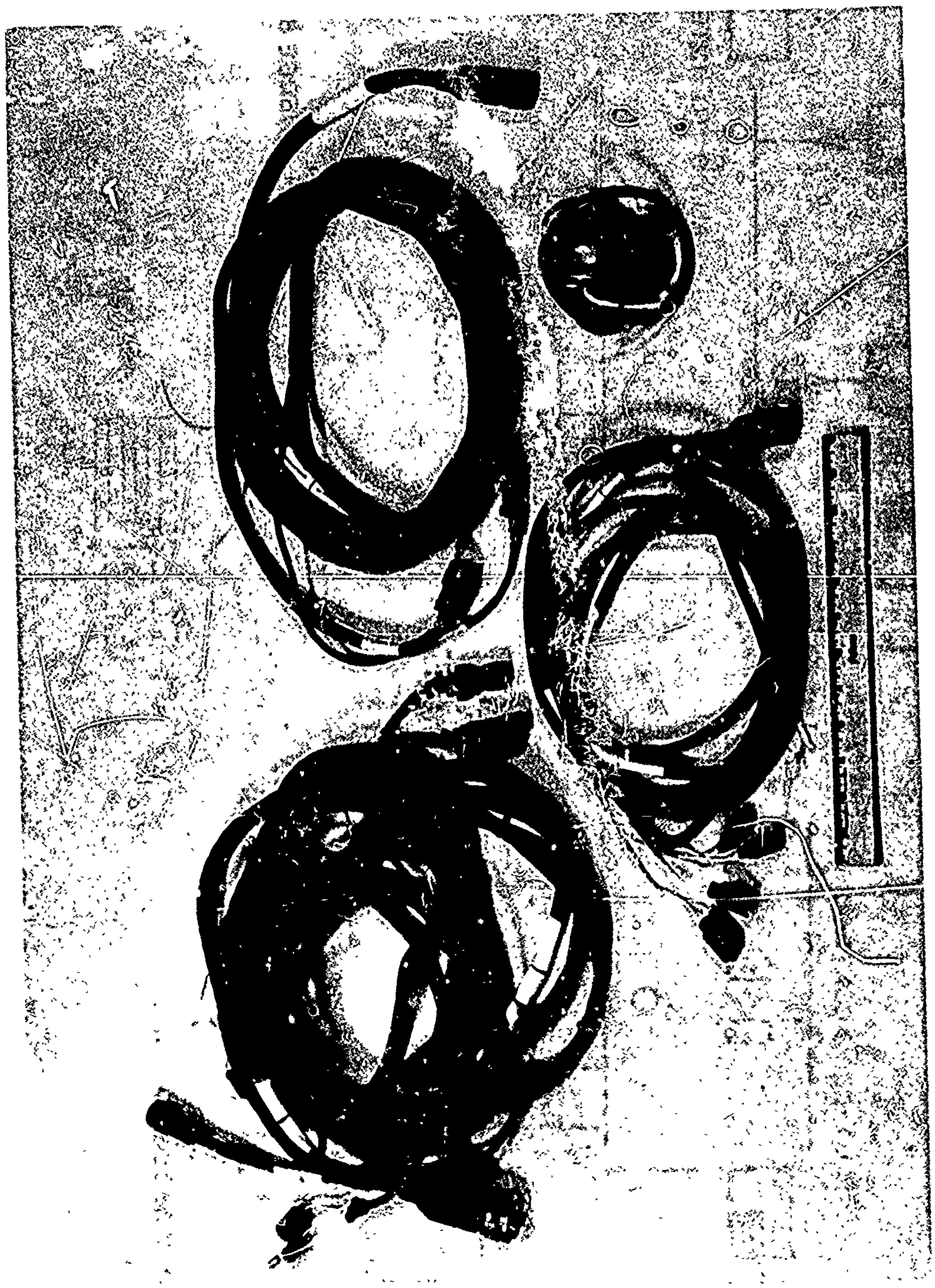


Figure 4-69. Interconnecting Cabling, Adapter Kit

87830

Three spare yellow weapon keys are supplied for use by the Tank Commander, gunner, and loader (of tanks) who wear MWLDs. *

The microphone assembly for sensing of the coax machine gun blank firing is included in the kits for tanks. Miscellaneous mechanical parts are supplied to provide interface between the vehicle and the MILES assemblies. A grounding strap assures that the LCA is properly grounded to the vehicle.

A unique feature of the vehicle interconnecting cabling is that the cable for any specific vehicle tells (by means of jumpers in the mating connector) the control console (LCA or CIA) in just what vehicle the LCA or CIA has been installed. The LCA and CIA need this information to perform the functions of kill probability determination and, for the LCA, the weapon complement that it must control. Although the adapter kits are similar and many components are common, the adapter kit for each vehicle is unique and not usable on any other vehicle. *

4.6 ANTITANK WEAPONS EFFECTS SIGNATURE SIMULATOR (ATWESS)

The ATWESS has been developed by XEOS as a part of the MILES program. It was designed to provide TOW, DRAGON and VIPER antitank weapons with a device, for use with MILES, that provides a credible simulation of audio and visual effects of actual weapon firing. Use of ATWESS thus enhances the tactical training scenario.

The ATWESS is comprised of a common universal firing device, a common pyrotechnic cartridge, and unique adapters for each of the weapons to be simulated.

4.6.1 FIRING DEVICE

The housing of the firing device, shown in figure 4-70, is cylindrical and sized to fit the LAW/VIPER launch tube, where it is attached by screws through the launch tube wall and into the housing of the firing device. For TOW and DRAGON launch tubes, adapter rings are used to interface the firing device and accommodate the larger launch tube diameters. The ATWESS firing device mounts in the rear of each of the launch tubes.

A firing chamber is sized to accommodate the ATWESS cartridge which looks very much like a large shotgun shell with a flange on the end opposite the primer. A hinged breech block door opens to allow insertion of the cartridge. Opening of the door performs the following functions:

a. Ejects the spent cartridge far enough for easy removal by hand

b. Cocks the firing mechanism

c. Places the safe/arm lever in the safety position

Set in the back of the breech block door are two contact springs, insulated from the door. When the door is closed the springs complete an electrical circuit which uses the cartridge face as a conductive

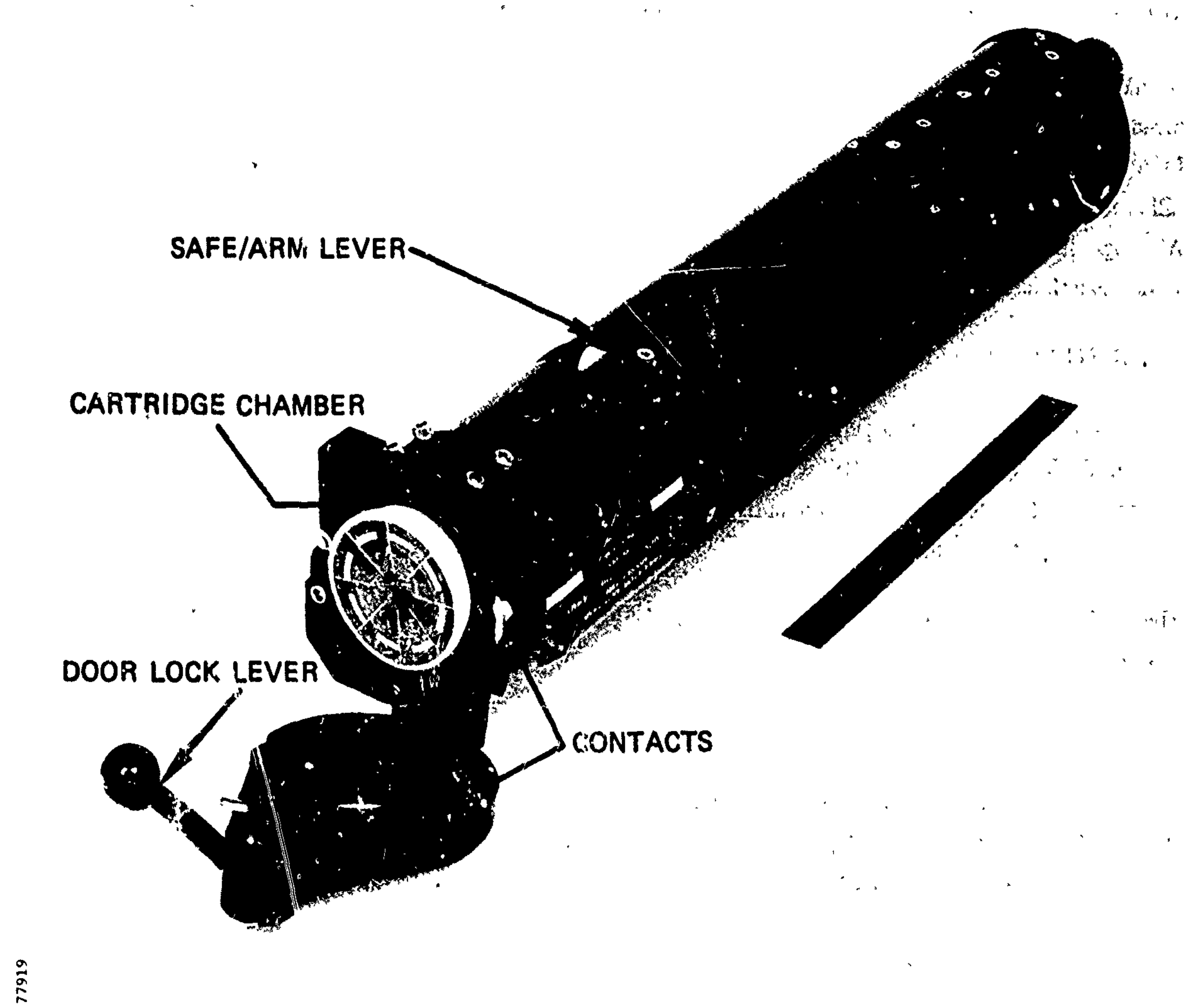


Figure 4-70. ATWESS Firing Device

path from one contact spring to the other. This circuit path must be complete for the MILES laser transmitter to fire. The plastic cartridge has a small printed circuit contact disc on its face which before the cartridge is fired provides the electrical path. When the cartridge is fired, the center of the contact disc is blown out and the circuit path is broken. Thus, the MILES will not fire again until a new ATWESS cartridge is inserted.

The ATWESS is fired when MILES is triggered. It must first be loaded and cocked as described above. The arming lever must then be pulled out into the arm position. This arming action accomplishes two things:

a. Withdraws a safety plate that in the safe position traps the firing pin

b. Closes a microswitch that is in series with a part of the MILES firing circuit

A simplified block diagram of the MILES/ATWESS firing circuit is shown in figure 4-71.

Actual firing of ATWESS is accomplished by a signal from the MILES transmitter. The ATWESS electronics charge a capacitor and keep it in a fully charged state. The capacitor discharge is used to operate a solenoid which releases the sear and trips the firing pin hammer. MILES battery power, 9 vdc, is used to charge the capacitor. The capacitor charges in 10 seconds or less and is thus ready for the next ATWESS firing. This is less than the normal reload time of the weapons being simulated. The ATWESS draws approximately 50 mA of current for each cartridge firing.

Maintenance of the ATWESS firing device is similar to that of a weapon. Carbon deposits from the cartridge firing collect on the breech block door and door handle and around the breech opening. The device should be cleaned at a minimum after each field operation, and ideally should be done daily if the device has been fired numerous times. The door hinge and door handle pivot are exposed to weather and to the carbon particles from the blast. They should be given a light coat of gun oil occasionally to prevent galling or binding of the mechanisms.

4.6.2 CARTRIDGE

The cartridge, shown in figure 4-72, is a three piece injection molded unit consisting of a cylindrical housing with a flange on one end, a snap-in primer plate, and a snap-in closure disc for the flanged end of the cartridge. The primer plate has a hole in its center to accept a standard MIL-Spec primer. This primer is M42C1 per MIL-P-20444. The closure disc has a circular relief groove which shears when the cartridge is fired. This disc is the containment for the pyrotechnic composition which produces the audible report.

Loaded into the aft end of the cartridge, prior to installation of the primer plate, is a preformed pyrotechnic pellet of magnesium teflon composition. It is contained within a cardboard tube. This cylindrical pellet is coated with a first fire composition which acts as a catalyst to accelerate the ignition of the pellet. The pellet provides the flash and smoke of the weapons effect signature.

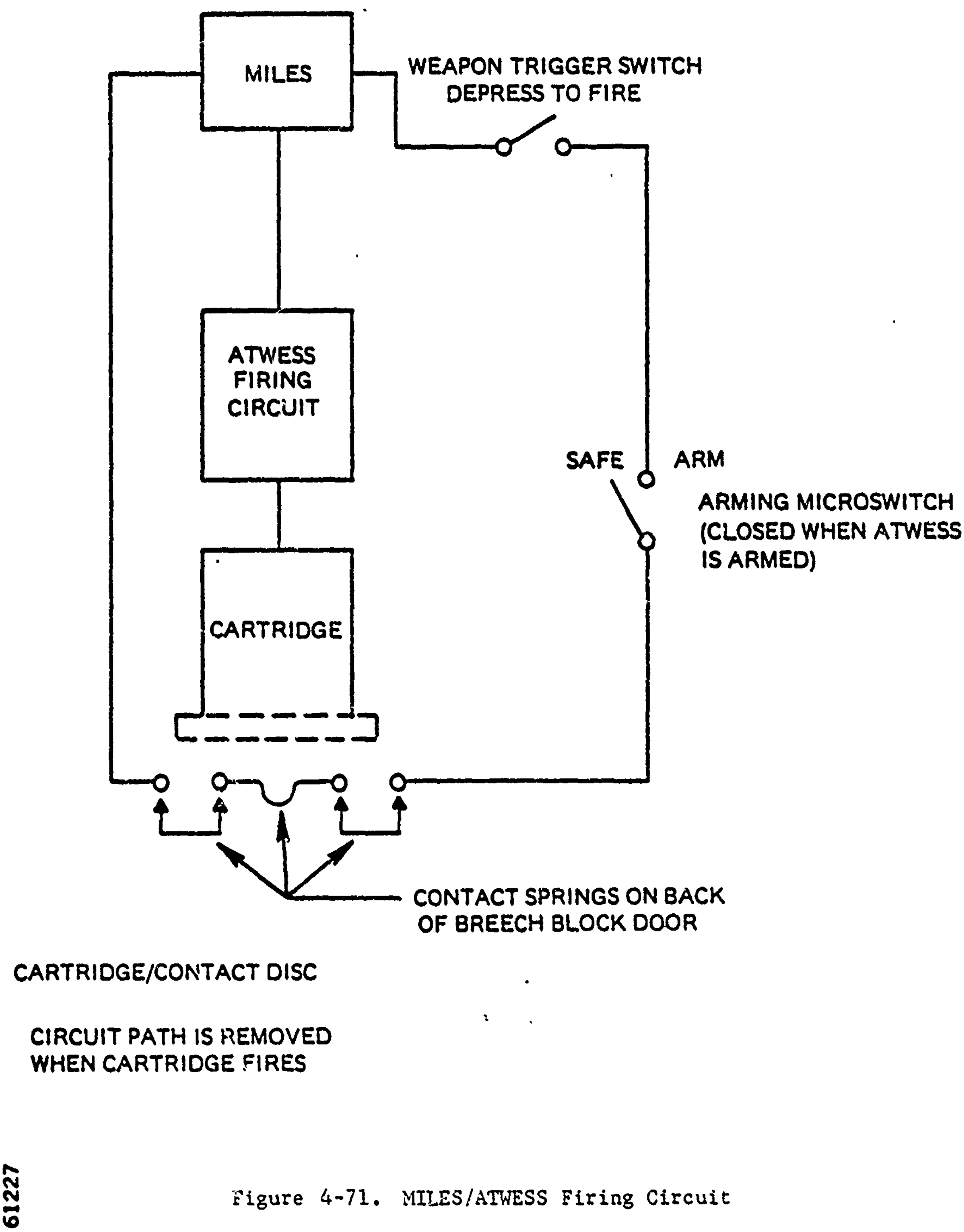


Figure 4-71. MILES/ATWESS Firing Circuit

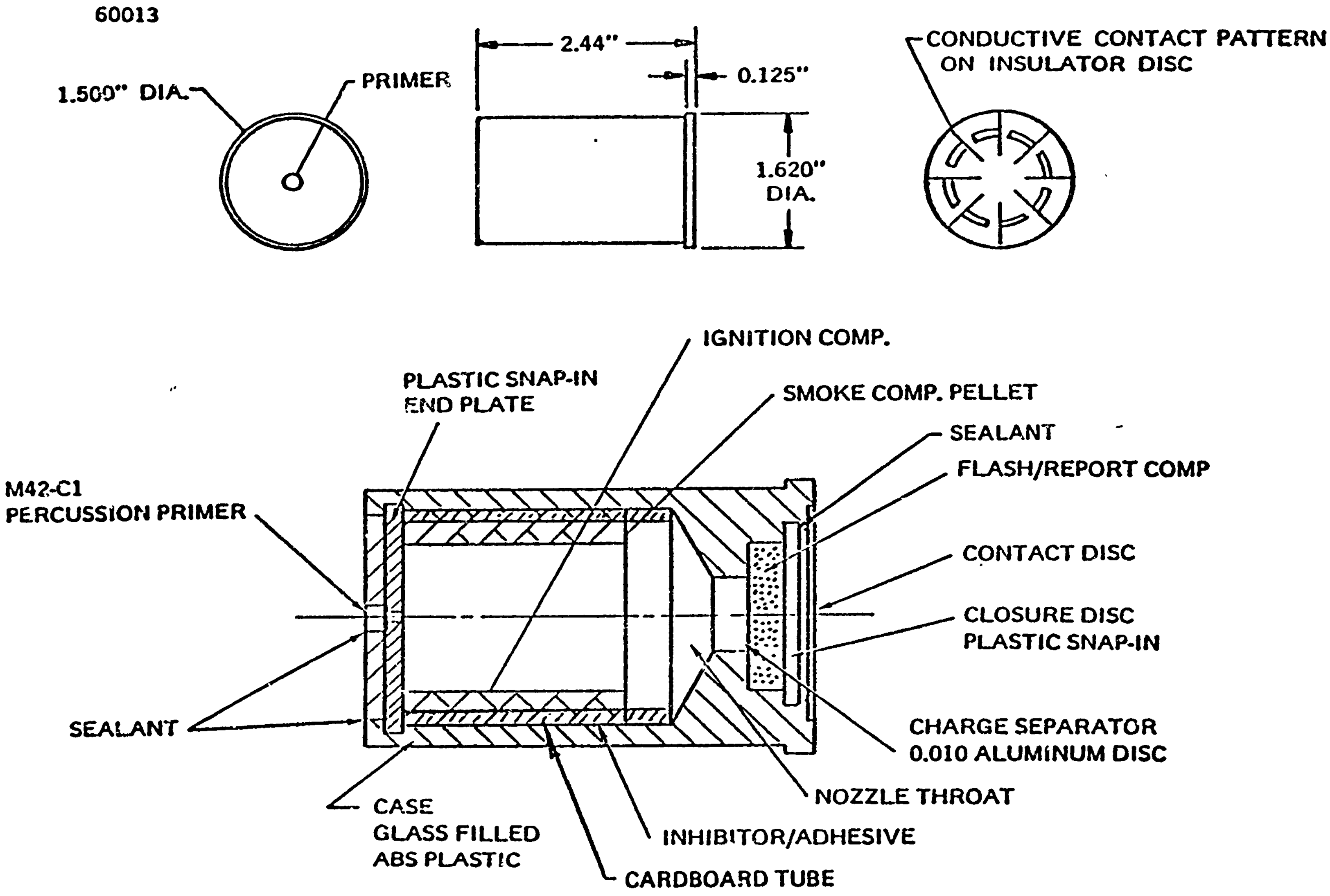


Figure 4-72. Weapons Effect Simulator Expendable Cartridge

An adhesive backed aluminum disc is placed at the cavity bottom on the other end of the cartridge as a separator wall between the pyrotechnic pellet and the bang composition chamber. Sixty milligrams of loose magnesium teflon mixture are loaded into the bang composition chamber and then the closure disc is snapped into place. All interfaces of the three plastic parts and the primer are made water tight with a sealant. Finally, the contact closure disc is bonded in place at the flanged end. The cartridge is complete except for identification. The finished cartridge is 1.5 inches in diameter by 2.44 inches long and weighs 1.9 grams.

4.6.3 ATWESS SIGNATURE

Firing of the ATWESS results in the following sequential events:

a. Report or Bang

b. Flash

c. Smoke

The report has a rise and decay time of approximately 2 milliseconds. Its maximum sound level is approximately 165 to 170 dB at one foot, which is typical of the distance from the ATWESS to the VIPER firer's ear. Figure 4-73 compares ATWESS with the DRAGON.

The flash when viewed in daylight appears to be 1 to 2 feet in diameter and approximately 7 feet in length (figure 4-74) and is visible even on a bright sunny day. The flash color varies with time from bright white to light orange. Total flash duration is 400 milliseconds. Figure 4-75 compares ATWESS with TOW and DRAGON.

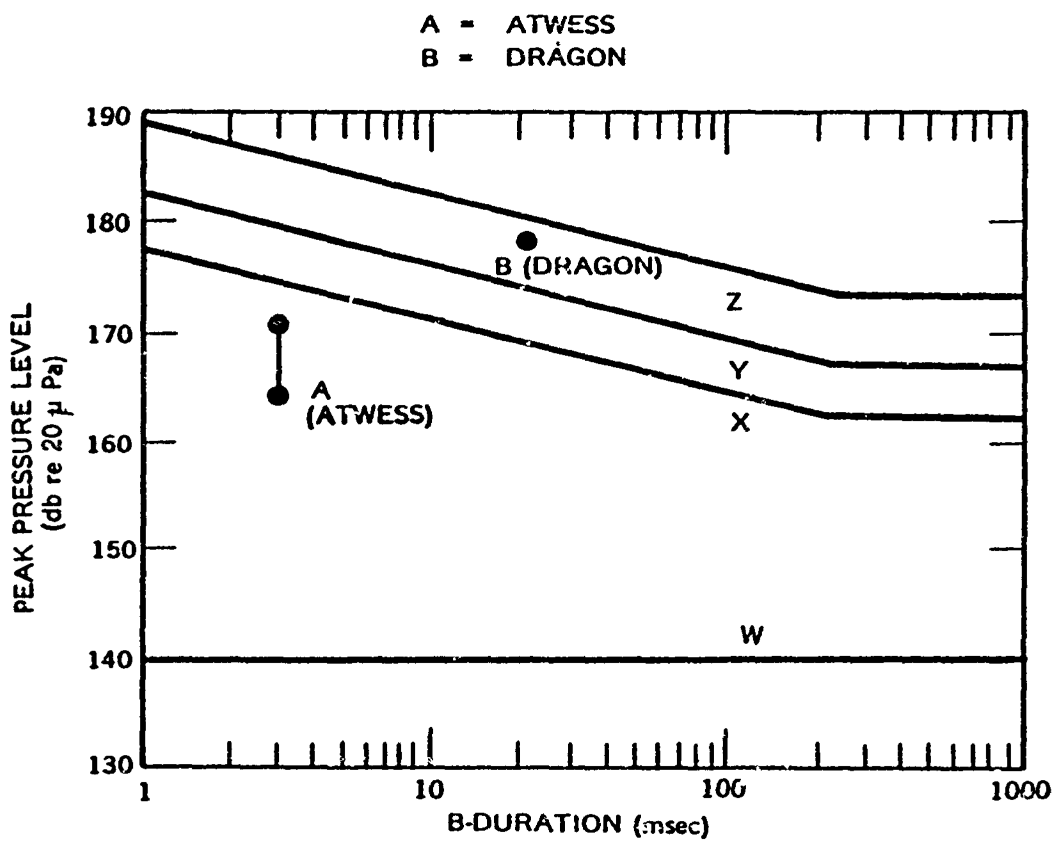
Smoke is produced in abundance and is white in color. It rises and dissipates fairly rapidly. Figure 4-76 shows the ATWESS smoke at 1.5 seconds after firing.

4.6.4 SAFETY

To avoid countertraining, personnel using the ATWESS should observe the same backblast and ear safety precautions that they do when using the actual weapons even though ATWESS is attenuated somewhat from the actual weapon signatures. Backblast areas for TOW, DRAGON and VIPER are shown in figures 4-77 through 4-79. Figure 4-80 is a plot of the ATWESS safe area test results. Ear plugs or muffs should be worn when firing ATWESS. A sound pressure map for ATWESS is shown in figure 4-81.

The ATWESS when fired shoots a flash to the rear 7 to 8 feet long and 1 to 2 feet in diameter. This flash is extremely hot (approximately 4000°F) and is the primary danger from the ATWESS. The plastic containment disc is severed, fractured, and potentially burned in the signature. However, parts of it could be expelled in the backblast area. By observing the actual weapon backblast areas a wide

● REQUIREMENT IS $\geqslant$ 140 db AND BELOW THE Y LINE OF FIG. 5 OF MIL-STD-1474A AT THE FIRER'S EAR



PEAK PRESSURE LEVEL AND B-DURATION LIMITS FOR IMPULSE NOISE (SEE TABLE 5 TO SELECT CURVE FOR USE. NOTE: USE OF LEVELS IN EXCESS OF LIMIT W REQUIRES MANDATORY HEARING PROTECTION PER TB MED 251.)

Figure 4-73. ATWESS Audio Signature

59458

- FLASH, 5 -10 FT. LONG X 2–4 FT. DIA. MAXIMUM
  DURATION APPROX. 400 msec
  MAX. FLASH AT APPROX. 140 msec
- SMOKE, 14–16 FT. LONG X 4–6 FT. DIA.
  SMOKE PERSISTS FOR SEVERAL SECONDS
  COLOR, WHITE

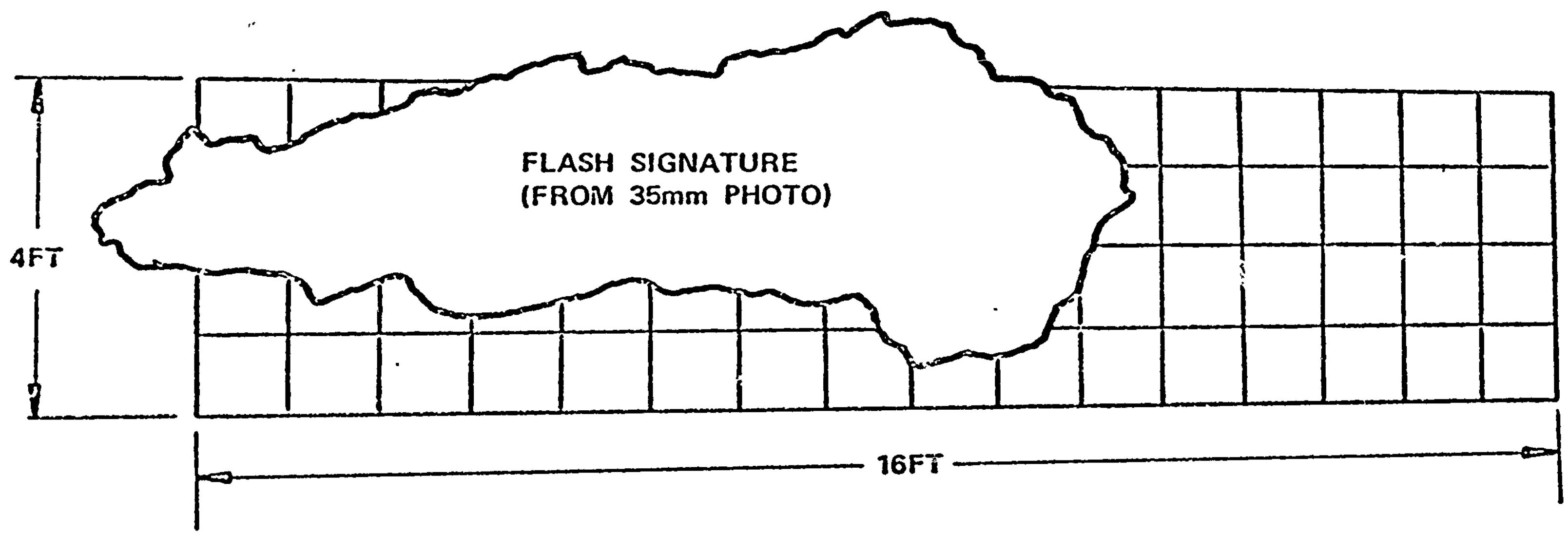
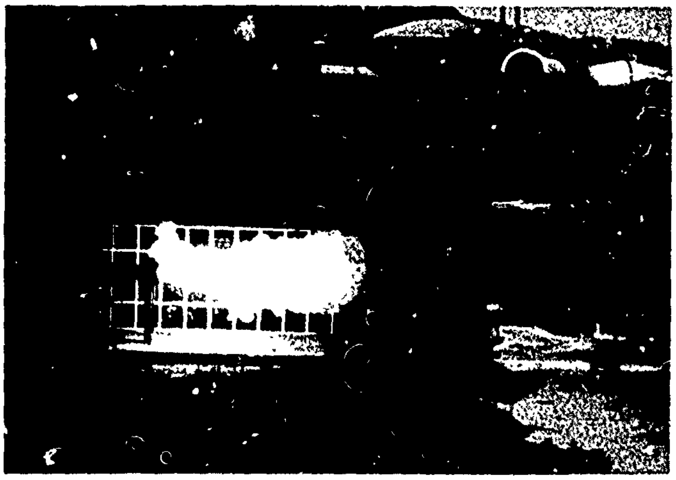


Figure 4-74. ATWESS Visual Signature

Figure 4-75. ATWESS Smoke Signature at t = 1.5 Seconds

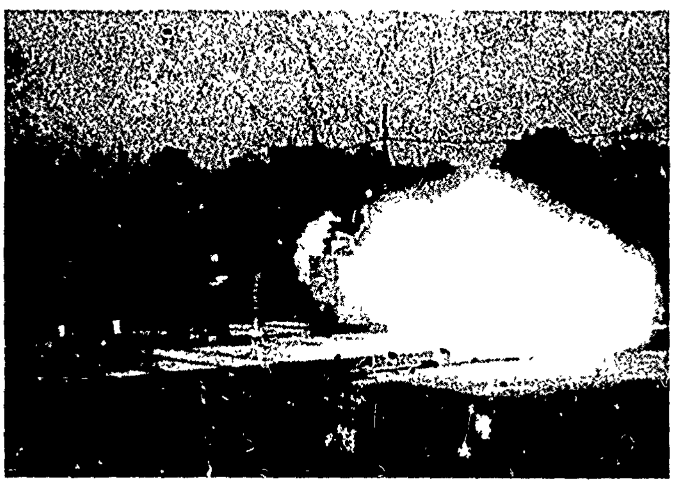
117722

TOW



117724

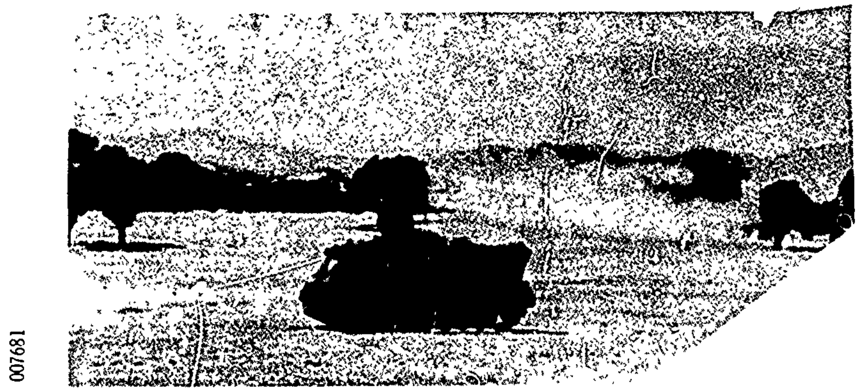
ATWESS



117721

DRAGON

Figure 4-76. Flash Signatures - TOW, ATWESS, and DRAGON



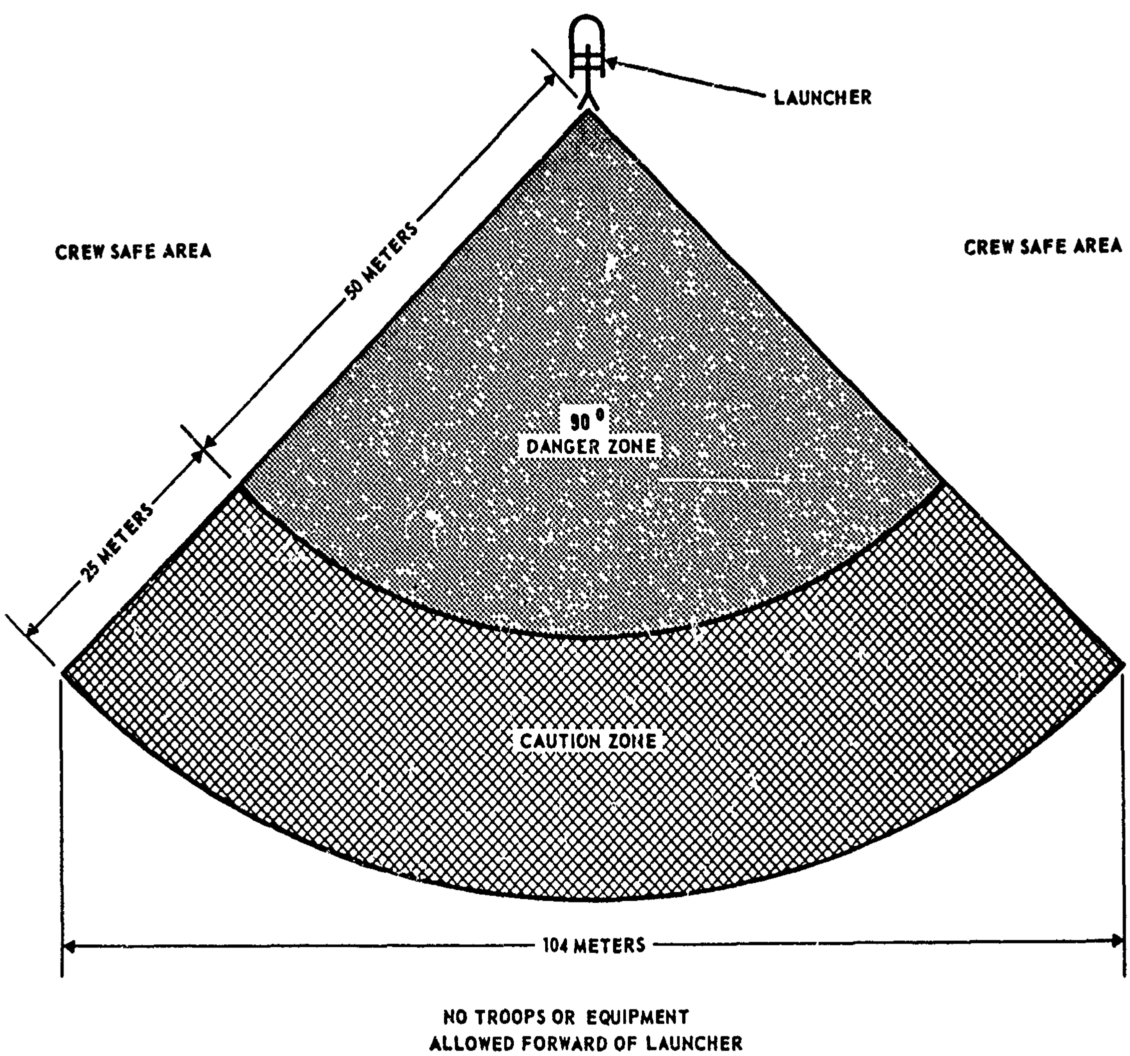


Figure 4-77. TOW (Actual) Missile Backblast Area

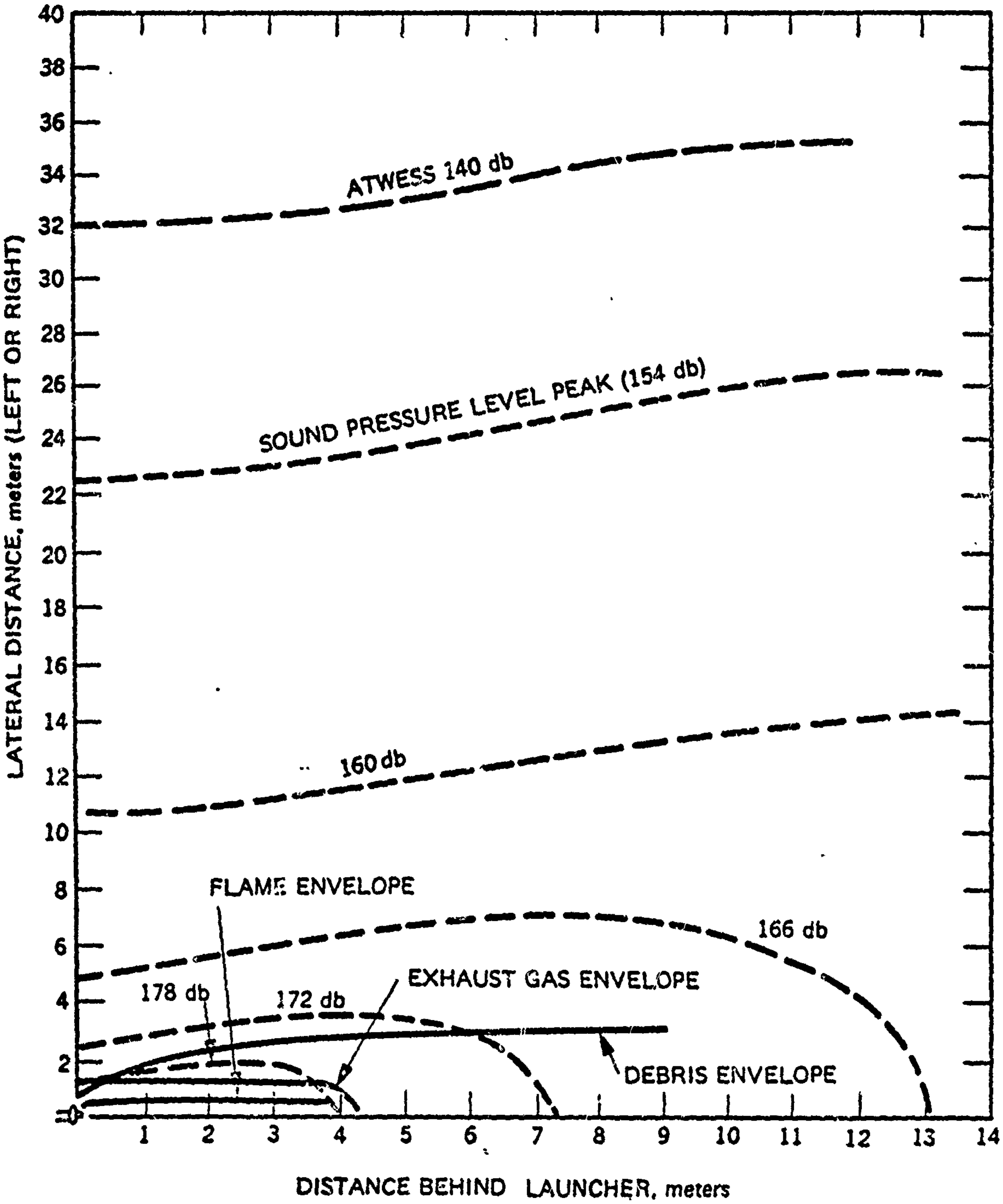
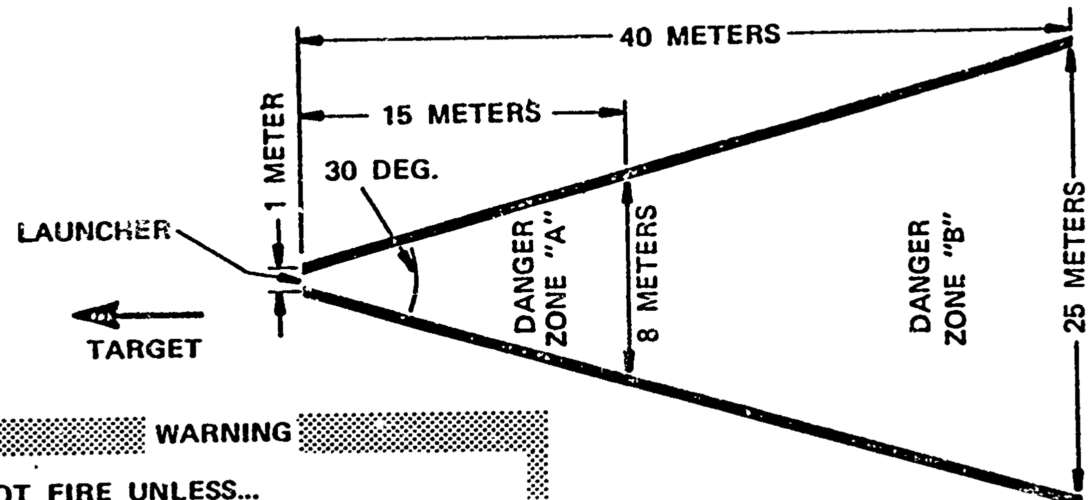


Figure 4-78. Dragon Sound Pressure Map

61061

61013



WARNING

DO NOT FIRE UNLESS...

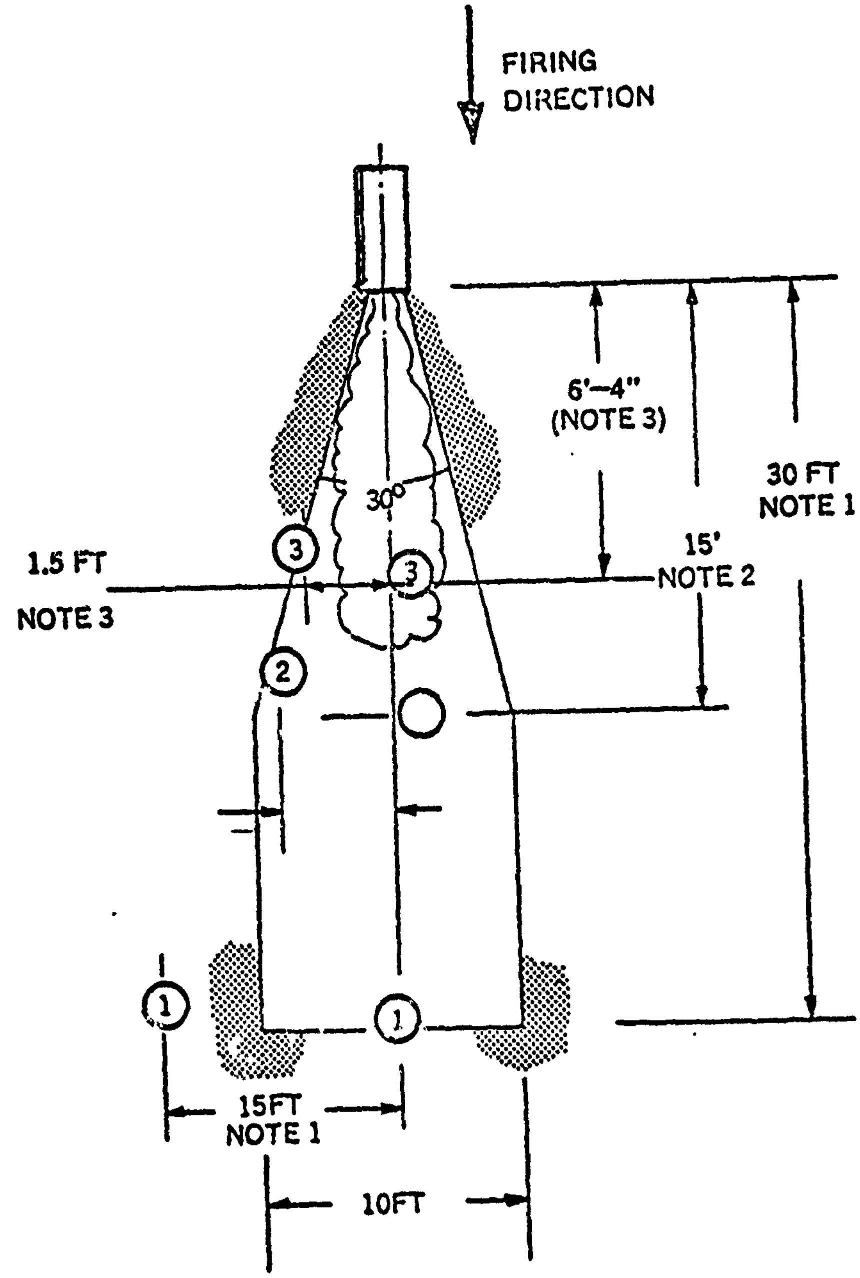
1. BACK BLAST AREA IS CLEAR OF PERSONNEL AND OBSTRUCTIONS.
2. BODY EXTREMITIES ARE CLEAR OF ROCKET EXHAUST END.

ZONE "A"
DANGER IN THIS AREA FROM BLAST, HEAT, AND PROJECTED MATERIALS.

ZONE "B"
DANGER IN THIS AREA FROM PROJECTED MATERIALS

WARNING: TREAT THE ATWESS AS YOU WOULD ANY LOADED AND ARMED WEAPON, A STRONG JOLT COULD TRIGGER THE ATWESS.

Figure 4-79. Viper Back Blast Danger Zones



NOTES:

1. 8X8 TEST WITNESS SCREENS SHOWED NO EFFECTS AT POSITION (1) ON EITHER SCREEN
2. WITNESS SCREENS SHOWED A SINGLE SCORCH ON THE IN–LINE SCREEN LOCATED 15FT FROM THE FIRING NO EFFECT ON THE SIDE SCREENS.
3. WITNESS SCREENS SHOWED A SPECKLED PATTERN ON THE IN–LINE SCREEN. NO EFFECT ON THE SIDE SCREEN.

Figure 4-80. ATWESS Safe Area Test Results

62447

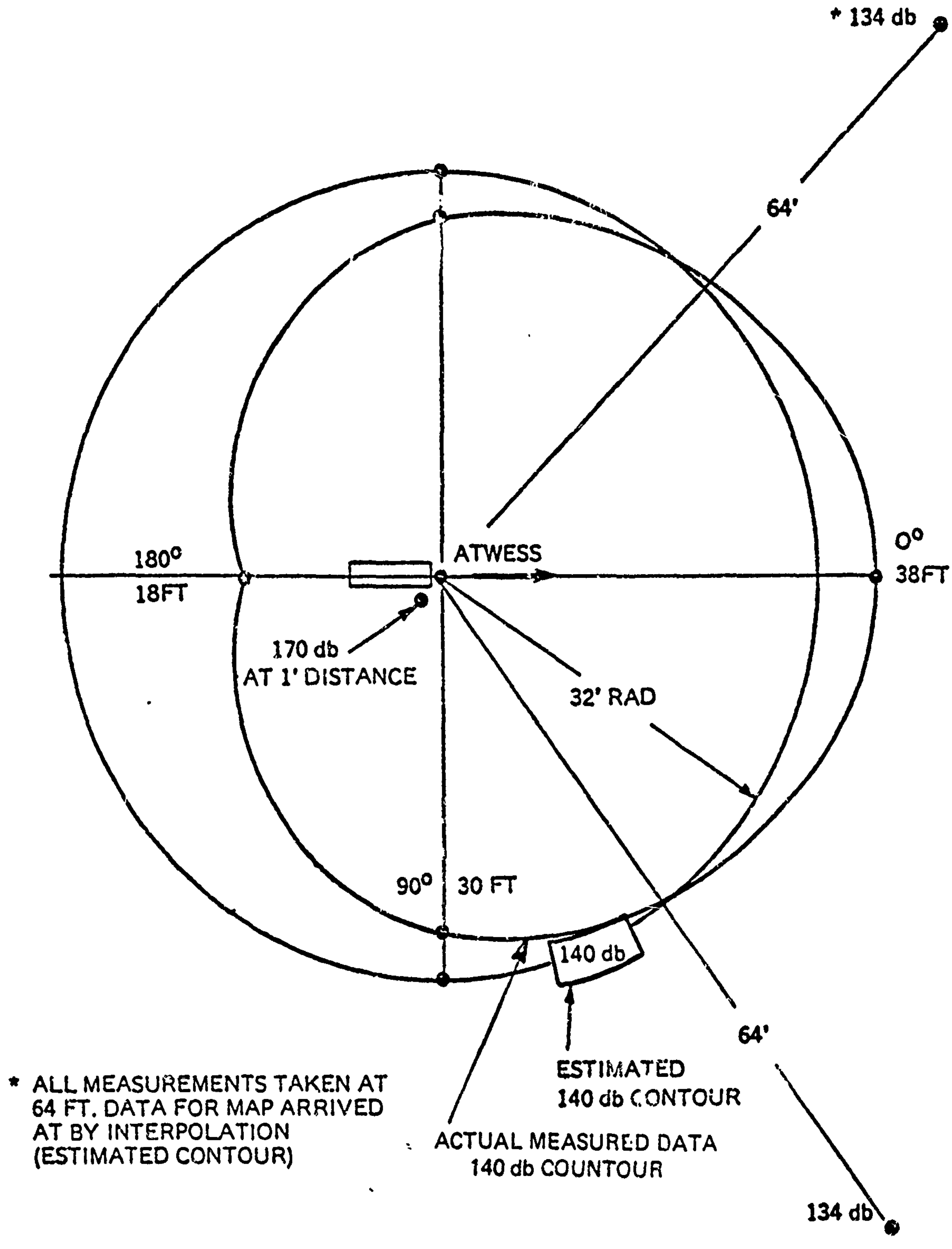


Figure 4-81. ATWESS Sound Pressure Map

62458

margin of safety will be imposed. The chemical components of the ATWESS cartridge are listed in table 4-2.

The smoke and by products of ATWESS firing are harmless. Analysis of the products of combustion is shown in table 4-3. The basic pyrotechnic mixture is used extensively in I.R. flares by the U.S. Air Force.

The ATWESS, as with any loaded weapon, should be kept in the SAFE condition and only ARMED when ready to fire at a target. Abusive handling or dropping the ATWESS in the armed condition could trip the hammer and cause ATWESS to fire.

ATWESS cartridges should be handled as with any live ammunition - with care. The cartridge case is a rugged glass filled plastic, but the primer cap must not be allowed to strike a sharp object.

4.6.5 PACKAGING AND SHIPPING

4.6.5.1 Cartridge

The basic requirement is to package the cartridge in cartons of 10 each. The XEOS approach to the cartridge packaging and shipping is shown in figures 4-82 and 4-83. The 10 cartridge carton weight is approximately 1.2 pounds and the 24 carton box weight is approximately 35 to 40 pounds. The shipping box is a standard 18 inches long by 12 inches wide by 12 inches deep, 200 pound burst strength cardboard box.

4.6.5.2 Firing Device

The firing devices will be mounted in their respective launch tubes and packaged and shipped as final launch tube assemblies.

4.6.6 MILES/ATWESS INTERFACE

4.6.6.1 Electrical/Electromechanical Interface

The electrical interface between the ATWESS and MILES for DRAGON and VIPER is shown in schematic block diagram form as figure 4-84. *

The electromechanical interface for VIPER is a cable and connector from the MILES transmitter to the ATWESS. The electromechanical interface for DRAGON is the connector that mates the DRAGON launch tube with the MILES simulated DRAGON sight. The electromechanical interface for the TOW is accomplished by means of the TOW bridge clamp connector which mates to the connector on the expended TOW launch tube. The wiring from the tube interior is properly mated by a connector to the ATWESS interface connector. *

TABLE 4-2

ATWESS CHEMICAL COMPONENTS

Part Name: Practice Cartridge, Cartridge Simulator
Part Number: 11749380
Chemical Components:

1. Pressed Smoke Composition - 14 Grams
   - 75% Magnesium
   - 15% Teflon
   - 10% Viton A [binder]
2. Ignition Composition - 0.5 gram
   - 25% Boron
   - 30% Potassium Perchlorate
   - 25% Barium Chromate
   - 10% Magnesium
   - 10% Viton A [binder]
3. Report Composition - 0.6 gram
   - 58% Magnesium
   - 38% Teflon
   - 4% Viton A [binder]
4. Primer
   - 1 each M42C-1

TABLE 4-3

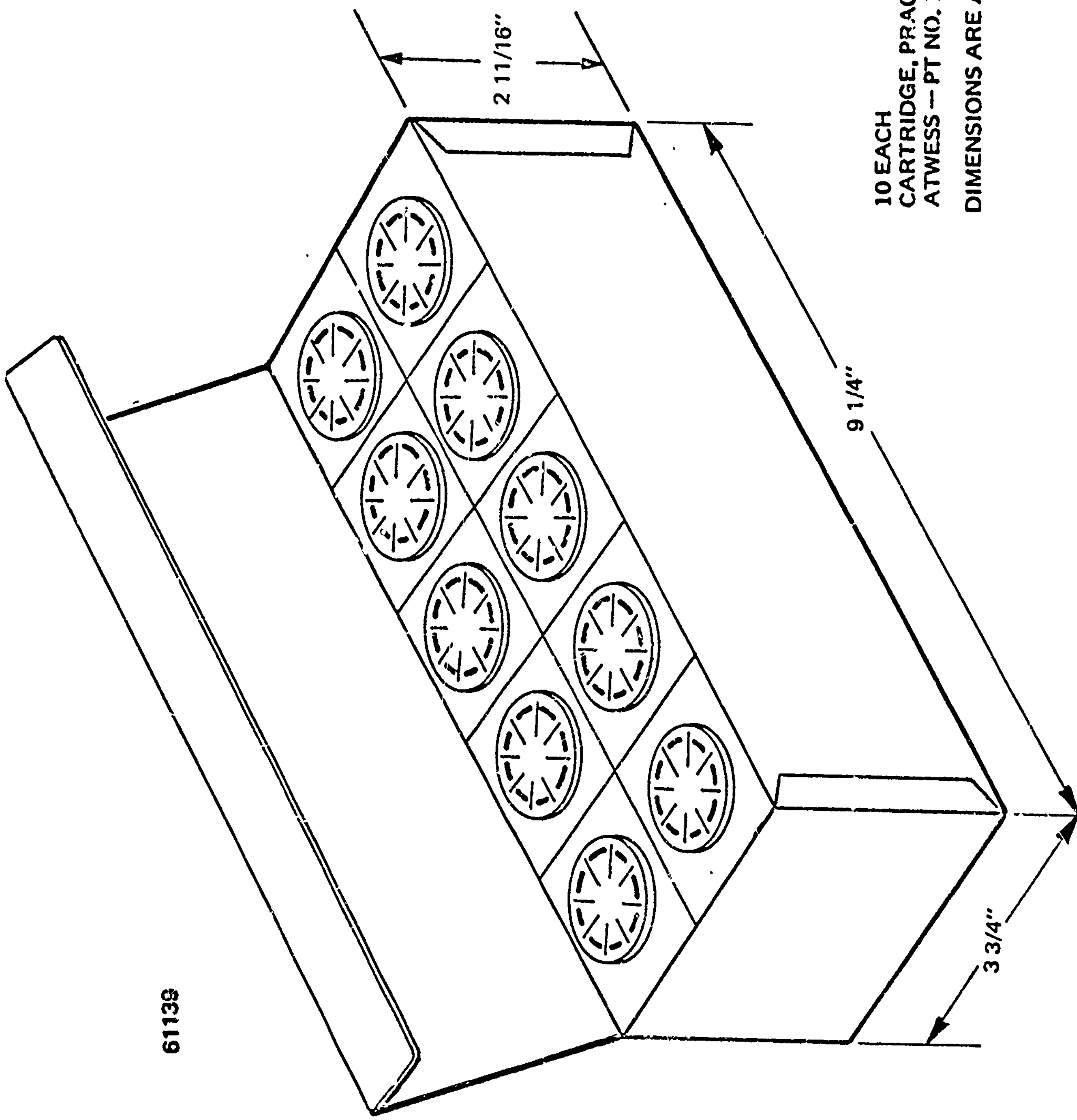
CHEMICAL RESIDUE EXPECTED FROM ATWESS CARTRIDGE FIRING

Magnesium Oxide	-	6.4 grams Solid
Magnesium Fluoride	-	6.4 grams Solid
Carbon	-	2.16 grams Solid
Boron Oxide	-	0.01 gram Solid
Potassium Oxide	-	0.01 gram Solid
Barium Oxide	-	0.01 gram
Cromium Oxide	-	0.02 gram

Plus less than 0.005 gram quantities of Zirconium Oxide, Iron Oxide. Silicon dioxide, and Nitrogen Gas.

Total Approx. 15 grams

This prediction is based on analysis of the same pyrotechnic used in another application.



61139

10 EACH
CARTRIDGE, PRACTICE
ATWESS — PT NO. 11749380

DIMENSIONS ARE APPROXIMATE

61140

MATERIAL: 200 LB. BURST STRENGTH CARDBOARD

LOADED: WEIGHT APPROX. 35–40 LBS.

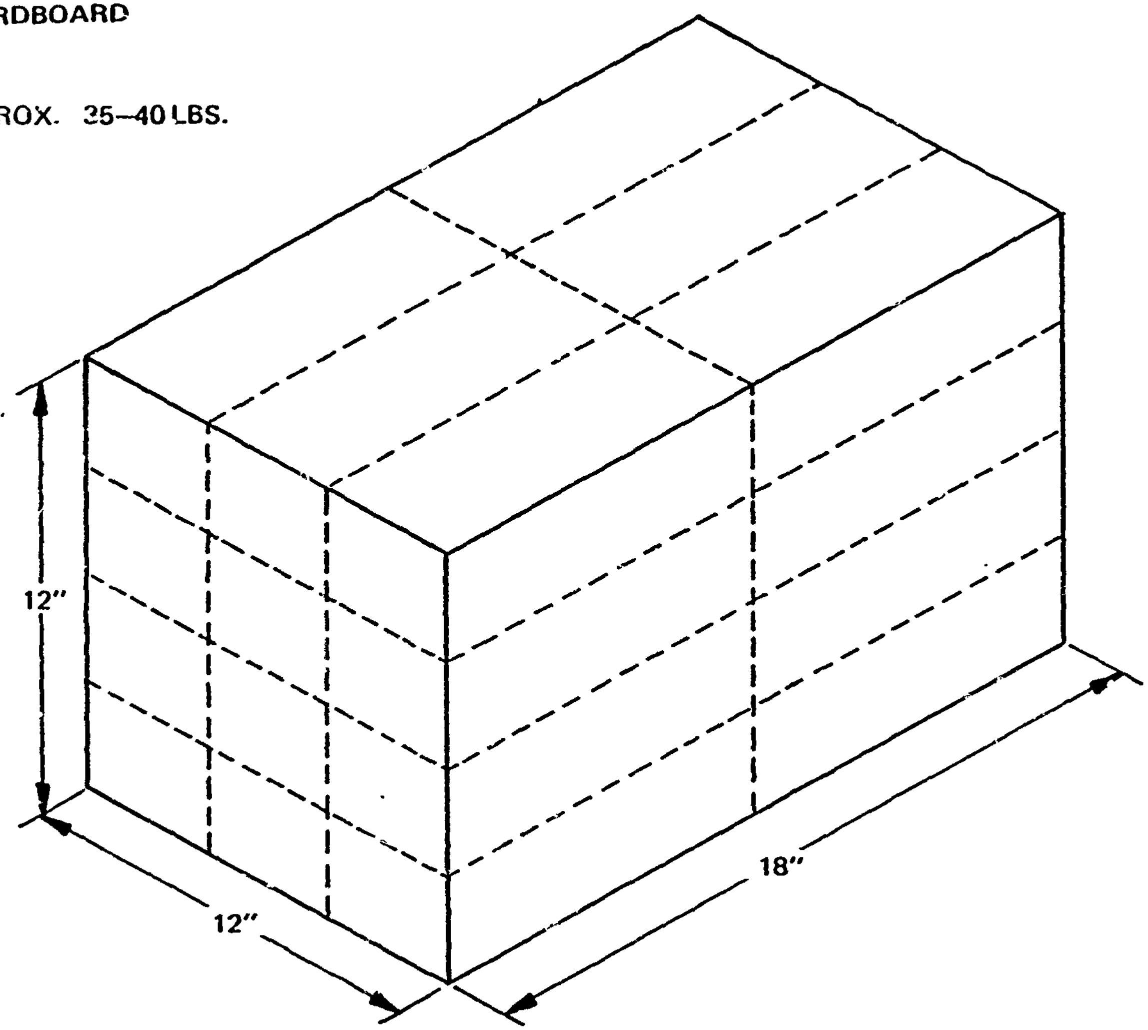


Figure 4-83. ATWESS Cartridge Shipping Container

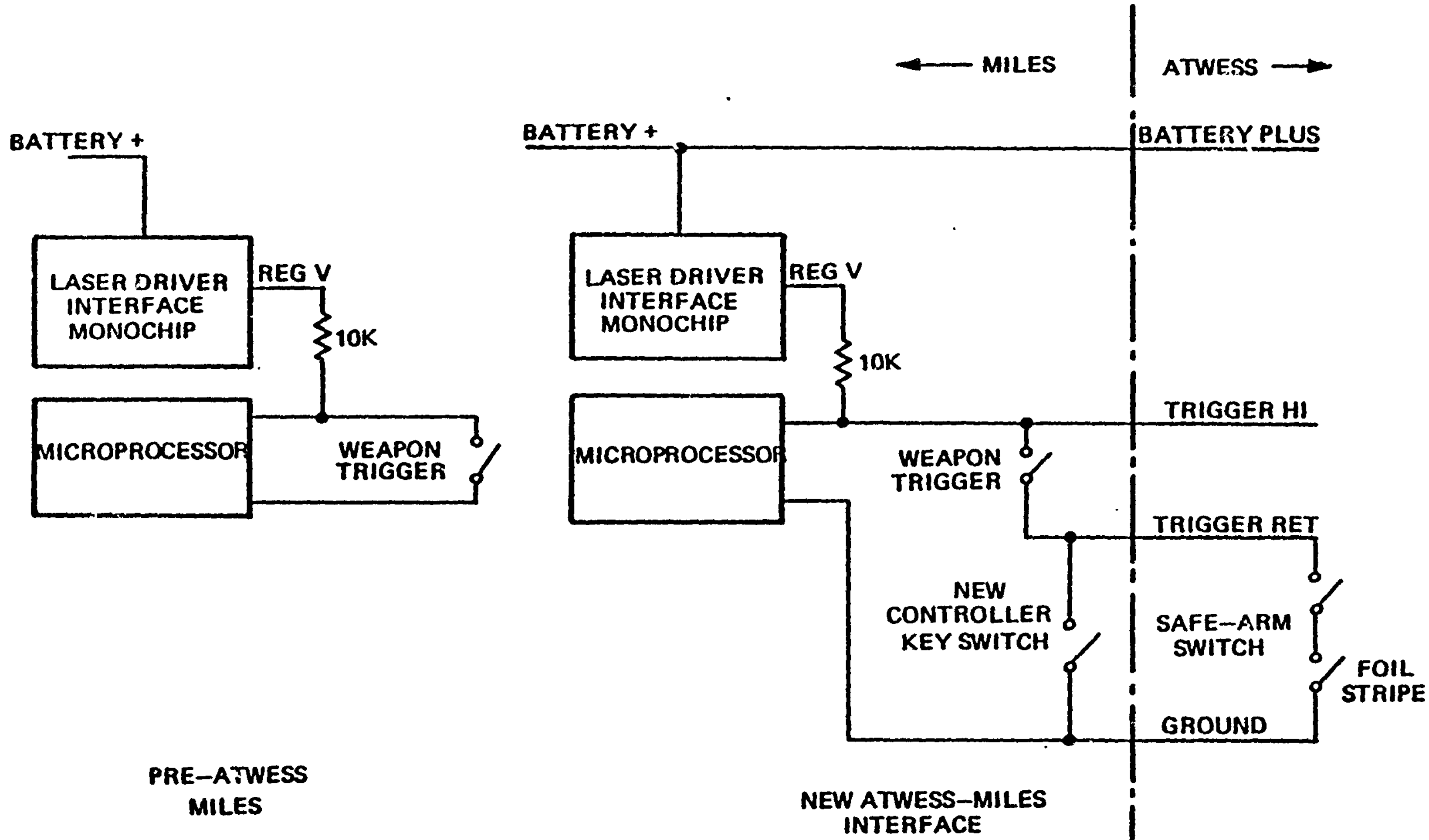


Figure 4-84. Dragon - Viper Electrical Interface

MILES has a capability for dry fire (i.e., firing without ATWESS). This capability can only be set by a controller who exercises the option with his controller key in the weapon key receptacle of the DRAGON or VIPER laser transmitter assembly. Dry fire for the TOW is accomplished by the controller setting a switch in the TOW MGS simulator to the dry fire position. This can only be done with the controller key. This switching function is shown schematically in figure 4-85.

4.6.7 SYSTEM APPLICATIONS

ATWESS is intended to be used with MILES for simulation of DRAGON, VIPER, and TOW antitank weapons. The system functional descriptions follow.

4.6.7.1 DRAGON

To fire the DRAGON simulator, the MILES laser transmitter (simulated DRAGON sight) must be mated to the ATWESS launch tube assembly. This is done in the normal manner used for attaching the actual DRAGON sight.

Firing is accomplished in the same manner as the normal DRAGON weapon except that the ATWESS must be armed before the MILES/DRAGON simulator will fire. When the DRAGON trigger is squeezed, ATWESS will fire immediately. One second later the MILES begins its laser transmission; The gunner must track the target for 6 seconds of laser transmission - 7 seconds from triggering. The expended ATWESS cartridge must be replaced before MILES or ATWESS will again fire. Figure 4-86 shows the DRAGON/ATWESS with the ATWESS breech open. *

4.6.7.2 VIPER

Since the Viper is designed to be used once and then discarded, it was found that an expended Viper launch tube was not sufficiently rugged to withstand the rigors of repeated use. Therefore, a new Viper tube, which simulates the external configuration and operational use, was developed. The simulated tube differs from the real Viper in that the simulated tube is solid and does not telescope. *

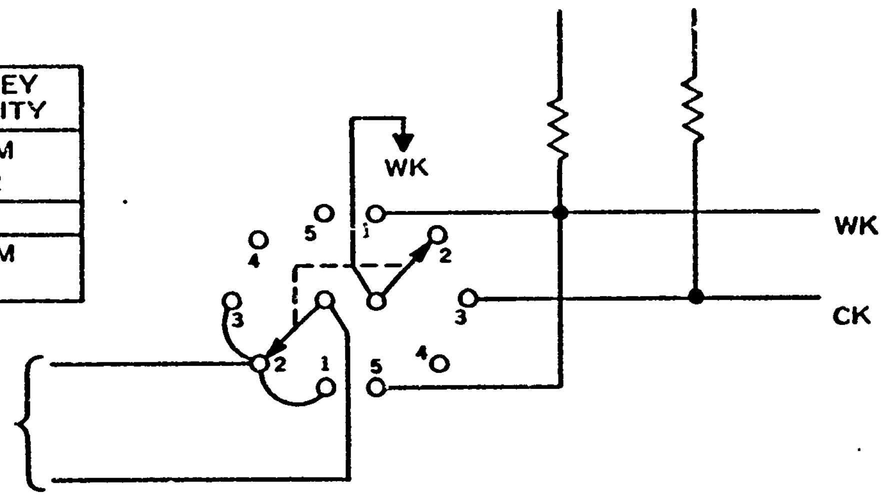
Firing is accomplished by loading an ATWESS cartridge into the rear of the Viper tube, pulling out the ATWESS safety lever to the armed position, aiming, and firing. The ATWESS and MILES both fire immediately when the trigger is depressed; no tracking is required. The expended ATWESS cartridge must be replaced before the Viper transmitter or the ATWESS will again fire. Figure 4-87 shows the Viper/ATWESS with a cartridge installed and the ATWESS breech closed and locked. *

4.6.7.3 TOW

The ATWESS firing device is mounted into an expended TOW launch tube by means of two cylindrical adapter rings. Electrical interface wiring completes the TOW ATWESS assembly. This assembly is then placed in the TOW firing platform and left for the duration of the training or firing exercise. ATWESS cartridges are loaded into the firing device and ejected after firing.

61212

SWITCH POSITION	MODE	MP INPUT	WEAPON KEY ACCESSIBLITY
1	DRY	WK	ONLY FROM
2	DRY	—	POSITION 2
3	DRY	CK	NO
4	ATWESS	—	ONLY FROM
5	ATWESS	WK	POSITON 4



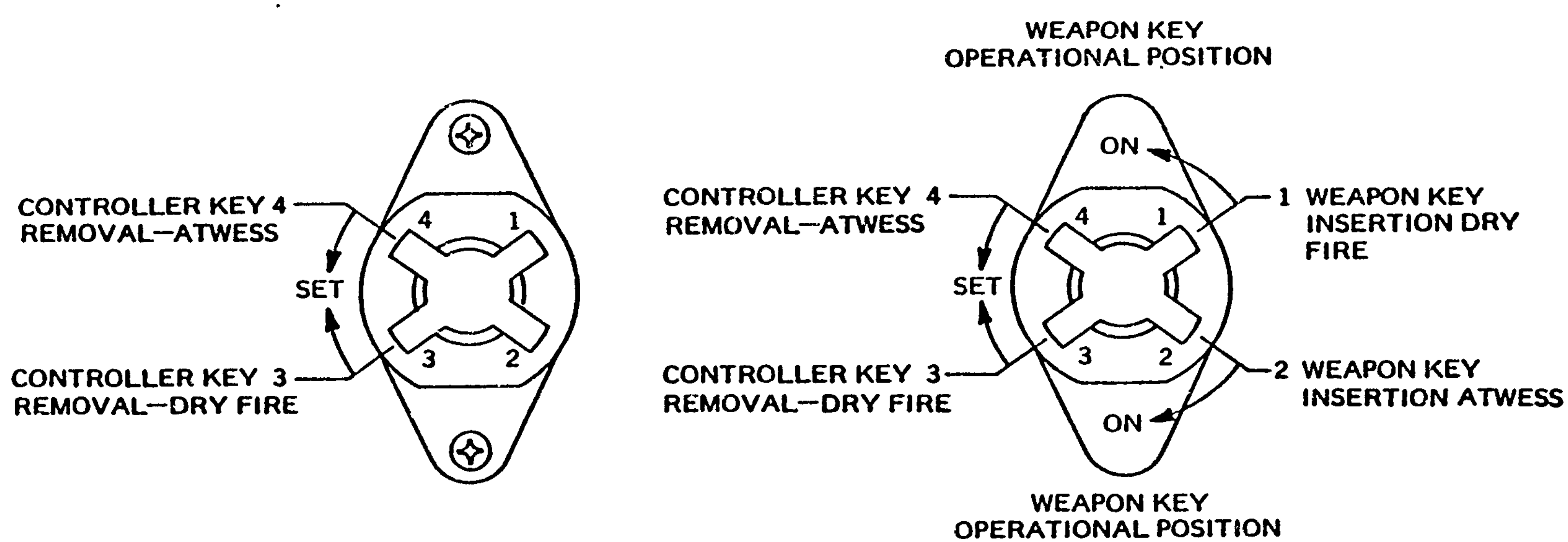
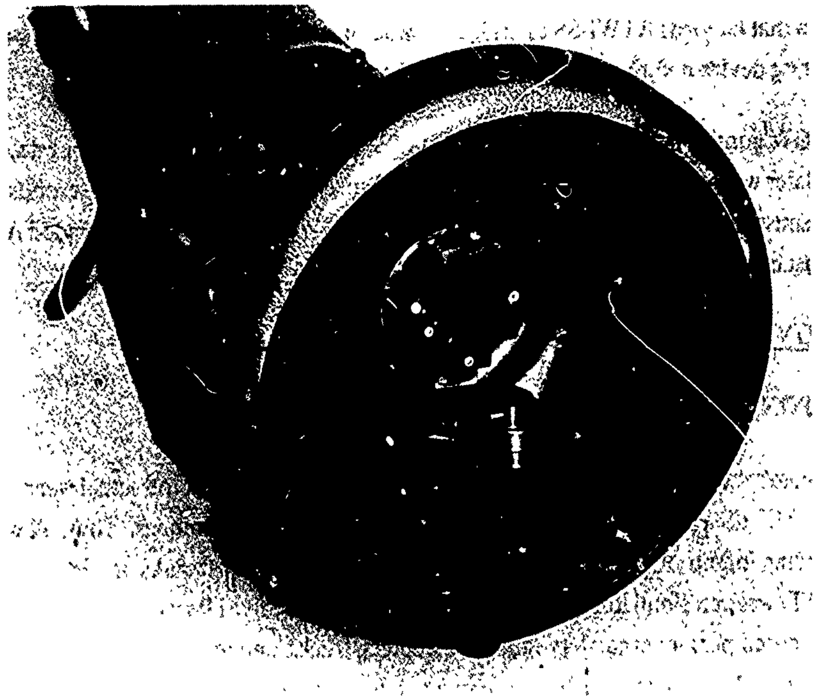
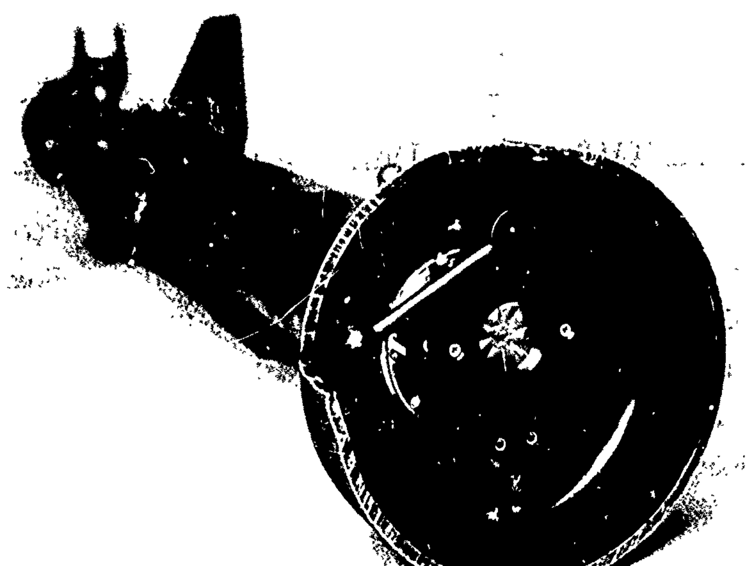


Figure 4-85. Dragon/Viper-to-ATWESS Switching



97932

Figure 4-86. Dragon/ATWESS System



97921

Figure 4-87. Viper/ATWESS System

Operationally, the TOW gunner goes through the same routine that he would with the real weapon with the exception that he loads ATWESS cartridges instead of launch tubes and that he must arm the ATWESS firing device before either MILES/TOW or ATWESS will fire.

When the TOW gunner triggers the weapon, ATWESS will fire immediately. After a 1-second delay, the MILES laser will start its transmission. The gunner must track his target for 10 seconds after the MILES transmission starts - 11 seconds from the time of TOW triggering. The expended ATWESS cartridge must be removed and replaced before MILES or ATWESS will again fire.

4.7 WEAPON SIMULATION

4.7.1 WEAPON HIERARCHY

As a part of combat tactical training realism, it is extremely important that the actual weapon hierarchy is preserved. MILES achieves this through its coding and decoding techniques. Thus, all weapons are capable of killing infantrymen, but the infantryman is ineffective against tanks or APCs. Table 4-4 lists the MILES ED weapon simulators and their effectiveness against five classes of targets: infantrymen (MWLD), armored personnel carriers, tanks, helicopters, trucks, and jeeps. Note that all hits on infantrymen are kills. Hits on vehicles are scored as hits or kills based on preselected probability of kill given a hit.

TABLE 4-4

TARGET/WEAPON HIERARCHY

	TARGET				
		CVLD			
WEAPON	MWLD	APC	TANK	HELICOPTER	TRUCKS AND JEEPS
M16 Rifle	Kill	-	-	Hit or Kill	Hit or Kill
M60 Machine Gun	Kill	-	-	Hit or Kill	Hit or Kill
M85 Machine Gun	Kill	Hit or Kill	-	Hit or Kill	Hit or Kill
M2 Machine Gun	Kill	Hit or Kill	-	Hit or Kill	Hit or Kill
Coax Machine Gun	Kill	-	-	Hit or Kill	Hit or Kill
DRAGON Missile	Kill	Hit or Kill	-	Hit or Kill	Hit or Kill
VIPER	Kill	Hit or Kill	Hit or Kill	Hit or Kill	Hit or Kill
TOW Missile	Kill	Hit or Kill	Hit or Kill	Hit or Kill	Hit or Kill
Shillelagh Missile	Kill	Hit or Kill	Hit or Kill	Hit or Kill	Hit or Kill
105mm Gun	Kill	Hit or Kill	Hit or Kill	Hit or Kill	Hit or Kill
152mm Gun	Kill	Hit or Kill	Hit or Kill	Hit or Kill	Hit or Kill

4.7.2 KILL PROBABILITY

The MILES electronics in the Control Indicator Assembly (CIA) or Loaders Control Assembly (LCA) receives incoming coded weapon hit signatures and then, based upon the weapon/target relationship, performs a decision of hit or kill based on predetermined first round kill probabilities. The first round kill probabilities are listed for ED MILES weapons and the anticipated MILES weapons of the 1980's in table 4-5 with their corresponding first round kill probabilities against men, trucks/jeeps, aircraft and helicopters, APCs and tanks.

Kill probability is executed after each hit detection which for vehicles is for each two code words. Thus, for an eight word coded "round," the kill probability is exercised four times. This routine simplifies the software and provides future flexibility for MILES systems. It has no effect on hit probability vs range, but provides a decreased probability of kill as the range increases. Figure 4-88 compares the P_{KILL} when kill probability is looked up only once per message, and with P_{KILL} when the probability is looked up after each hit detection (two words). This graph shows how the MILES P_K given a hit routine reduces P_{KILL} as the range increases. *

4.7.3 WEAPON BASIC LOADS AND FIRING RATES

The MILES logic provides basic ammunition loads and firing rates based on the weapon and in many cases the vehicle in which the weapon is being used. The system was designed to provide for future growth into the 1980's so the CATB weapon's matrix was used to provide basic loads and firing rates in the ED MILES for both ED and future weapons. These weapons, their basic loads and firing rates, are shown in table 4-6.

4.7.4 EFFECTIVE RANGE

Ranges are specified as minimum effective ranges and the MILES equipment is designed to meet these ranges. The ranges are specified as follows:

WEAPON	KILL(meters)	NEAR MISS(meters)
M16A1 Rifle	5 to 460	5 to 460
M60 Machine Gun	5 to 800	5 to 100
Coax Machine Gun	5 to 800	5 to 100
105mm Gun	50 to 3000	50 to 3000
152mm Gun	50 to 2000	50 to 2000
VIPER Missile	10 to 300	10 to 300
DRAGON Missile	50 to 1000	50 to 1000
TOW Missile	50 to 3000	50 to 3000
Shillelagh Missile	800 to3000	800 to 3000

TABLE 4-5. KILL PROBABILITY

CODE WORD 110--------	WEAPON	WEAPON CODE NO	SINGLE ROUND KILL PROB PERCENT Tanks/ M551	Aircraft Helicopter	M113 APC	Trucks/ Jeeps
00101101	Controller Gun, Universal Hit, 100%	00	100.000	100.000	100.000	100.000
10010011	Maverick	01	100.000	100.000	100.000	100.000
00110101	TOW, Shillelagh, 100%	02	100.000	100.000	100.000	100.000
00101011	Dragon, 100%	03	100.000	100.000	100.000	100.000
01010011	Viper, 100%	04	100.000	100.000	100.000	100.000
10101001	152mm, 100%	05	100.000	100.000	100.000	100.000
01100101	105mm, 100%	06	100.000	100.000	100.000	100.000
11011000	TOW, Shillelagh, Sagger, Hellfire (ASH	07	96.875	100.000	100.000	100.000
10110100	Dragon	08	87.500	100.000	100.000	100.000
11001001	M202 Flame	09	78.125	100.000	62.500	100.000
01101001	M21 Anti-Tank	10	62.500	100.000	78.125	100.000
01001011	Claymore M81A1, M16 Mine	11	0.000	78.125	0.000	85.938
10110010	105mm	12	71.875	96.875	87.500	96.875
11001010	152mm, 155mm, 8 in., 105 Howitzer	13	68.750	96.875	84.375	96.875
01011001	2.75 in. Rocket	14	21.875	96.875	75.000	96.875
10101100	Viper	15	56.250	62.500	84.375	96.875
01010101	120mm	16	73.438	96.875	89.063	96.875
10010101	90mm	17	65.625	96.875	82.813	96.875
01100011	75mm, 73mm, Russian APC	18	62.500	96.875	81.250	96.875
10110001	Grenade (40mm	19	0.000	56.250	3.125	56.250
11000101	Rockeye, Cluster Bomb	20	3.125	81.250	75.000	81.250
11010100	GAU-8, AH (30mm)	21	62.500	84.375	75.000	84.375
00110011	Bushmaster (25mm, ZU23-4 23mm)	22	0.000	50.000	9.375	43.750
10001011	Vulcan, Airborne (20mm)	23	0.000	18.750	9.375	43.750
00010111	M2 or M85 (.50 Cal)	24	0.000	15.625	6.250	37.500
10001101	Roland II, Chaparrel	25	0.000	96.875	0.000	0.000
01001101	Stinger	26	0.000	85.938	0.000	0.000
01000111	M16 Rifle, M60 and Coax Machine Gun	27	0.000	9.375	0.000	9.375

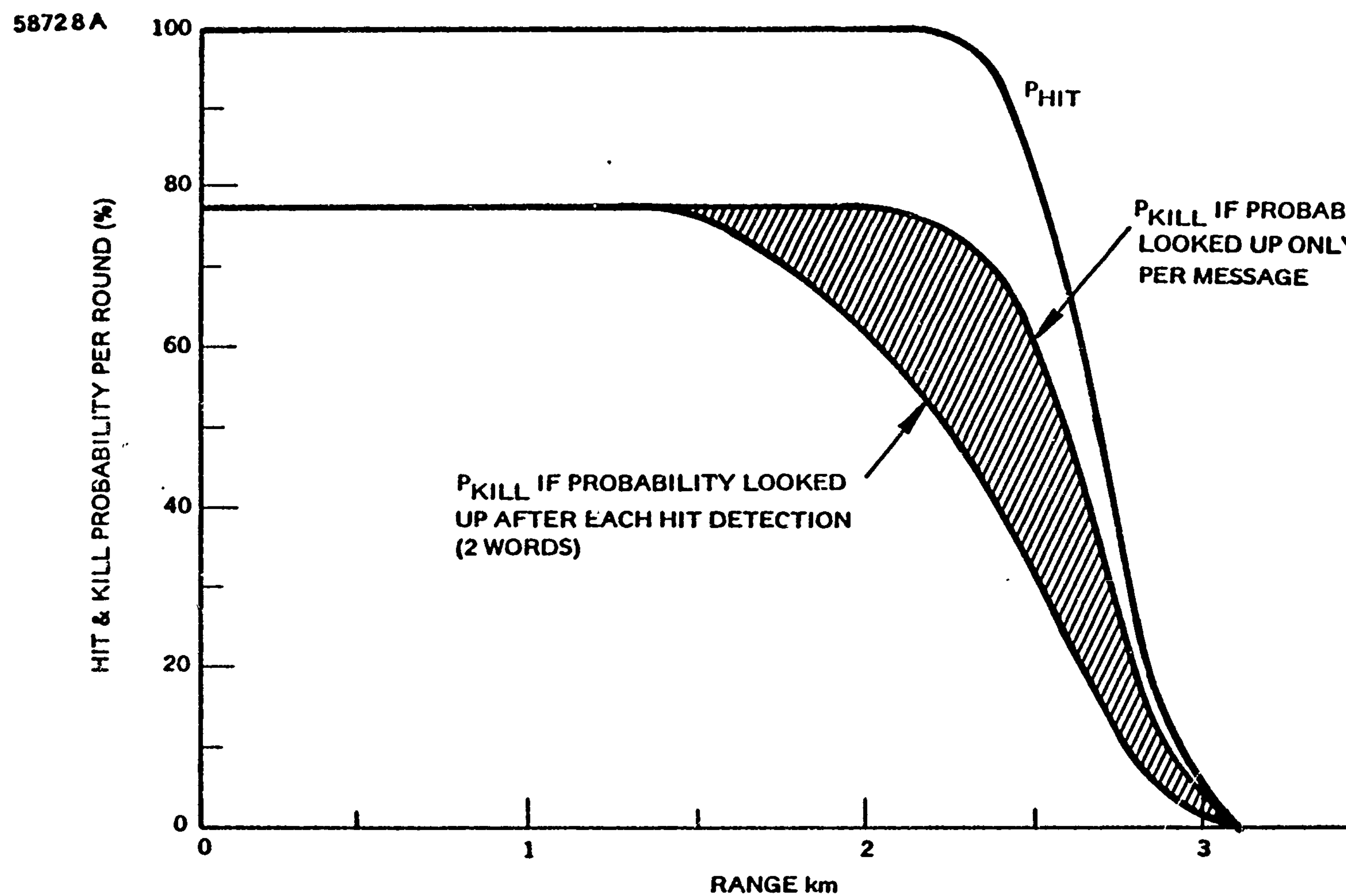


Figure 4-88. Comparison of Kill vs Range Curves for Two Kill Probability Alternatives

TABLE 4-6

MILES WEAPON SIMULATION

Weapon	Basic Load [Actual]	Basic Load MILES	Firing Rate [Actual]	Firing Rate MILES	Code Hit/NM	Source
			SLOW FIRE WEAPONS			
100 %105mm	63	63	12	12	6/28	Specification
100%, 152mm	63	30	6	6	5/28	Specification
2.75 in. Rocket [4 pods]	76	76	-	470	14/28	Army Ref. Guide
73mm Russian APC	30	30	-	8	18/28	MILES Task III Report
105mm	63	63	12	12	12/28	Specification
120mm English	53	53	-	12	16/28	Janes, pg. 346
152mm (M551)	20	20	6	6	13/28	Specification
152mm [M60A2]	33	33	6	6	13/28	Specification
8 inch Howitzer	-	99	0.5	2	13/28	Janes, pg. 412
105mm Howitzer	-	99	3	3	13/28	Janes, pg. 419
Maverick	-	4	-	2	1/28	Estimate
Chaparral	12	12	6	4	25/28	MILES Task III Report
40mm Grenade Launcher	300	99	400	133	19/29	Army Ref. Guide
90mm M48	60	60	-	12	17/28	Janes, pg. 356
Viper	4	4	6	6	15/28	Specification
			RAPID FIRE WEAPONS			
M73/219 Coax]7.62mm] M60 Helo	1800	1800	650	682	27/29	Specification
Minigun, M28 Helo	4000	4000	1300	1360	27/29	Army Ref. Guide
Minigun, M28 Helo	4000	4000	4000	4090	27/29	Army Ref. Guide
Minigun, 7.52mm M27E1 Helo	2000	2000	2000	2045	27/29	Army Ref. Guide
20mm M97 Airborne	750	800	750	744	23/29	Army Ref. Guide
Vulcan 20mm	1100	1100	1000	1023	23/29	Janes, pg. 100
Vulcan 20mm	1100	1100	3000	3273	23/29	Janes, pg. 100
Vulcan 20mm [Airborne]	1200	1200	6000	5455	23/29	Janes, pg. 519
ZU23-4	-	1800	4000	4090	22/29	Janes, pg. 101
GAU-8 30mm	1350	1400	2000	2045	21/28	Janes, pg. 518
GAU-8 30mm	1350	1400	4000	4090	21/28	Janes, pg. 518
XM-188 [AH] 30mm	600	600	2000	2045	21/28	Janes, pg. 521
M16A1	210	210	650	682	27/29	Specification
M2 Machine Gun	600	600	650	682	24/29	Specification
M85 Machine Gun	1200	1200	650	682	24/29	Specification
M60 Machine Gun	1200	1200	650	682	27/29	Specification
			MISSILES			
100% TOW; Shillelagh	10	10	4	4	2	Specification
TOW	10	10	4	4	7	Specification
Shillelagh [M551]	9	9	4	4	7	Specification
Shillelagh [M60A2]	13	13	4	4	7	Specification
Hellfire	16	16	6	4	7	Estimate
Dragon	10	10	4	4	8	Specification

4.8 KILL/HIT/MISS INDICATORS

The indications for kill, hit, or near miss are common throughout the MILES system. Both audio and visual indications are used to alert individuals and controllers to infantry and vehicle status.

4.8.1 AUDIO INDICATORS

For the infantry systems, there is an alarm mounted on the left shoulder position of the MWLD harness approximately 9 inches from the soldier's ear (see figure 4-89). This alarm has a peak sound intensity of 65 to 78 dB at 12 inches at a frequency of 2900 +500 Hz.

The vehicle's audio indicator is an audio tone which is inserted into the vehicles intercom system. The vehicle horn has a peak sound intensity of 115 dB at 5 feet at a frequency of 100 to 500 Hz. The audio indications used are as follows:

a. Hit - (Vehicles only, not on the MWLD) - Indicates a hit, but not a disabling kill. A series of four to six beeps over a four second period. *

b. Near Miss - Two beeps.

c. Kill - A continuous audio tone - requires a key insertion into a weapon key receptacle to shut off the alarm.

For the TOW system, an audio indicator is installed in the Missile Guidance Set (MGS) Simulator. This device plugs into the coil cord of the TOW traversing unit. If the detectors installed on the TOW tracker head receive a valid hit or near miss from an opposing MILES-equipped weapon, the alarm on *
the MGS is actuated. The alarm is identical to the one installed on the MWLD. The alarm beeps twice *
for a near miss and operates continuously for a kill.

4.8.2 VISUAL INDICATIONS

There are no visual indicators on the MWLD infantry systems.

Vehicle system visual indicators are as follows:

a. Hit - CVKI flashes four to six times.

b. Near Miss - CVKI flashes two times.

c. Kill - There are two indicators, one internal and one external to the vehicle. Internally, the NOT READY light on the Control Console or Control Indicator illuminates and remains on until cleared by a Controller Key in the weapon receptacle of the Control Console or Control Indicator (see figures 4-64 and 4-65). Externally, the CVKI strobe light is activated and flashes continuously until the vehicle system is reset by the Controller.

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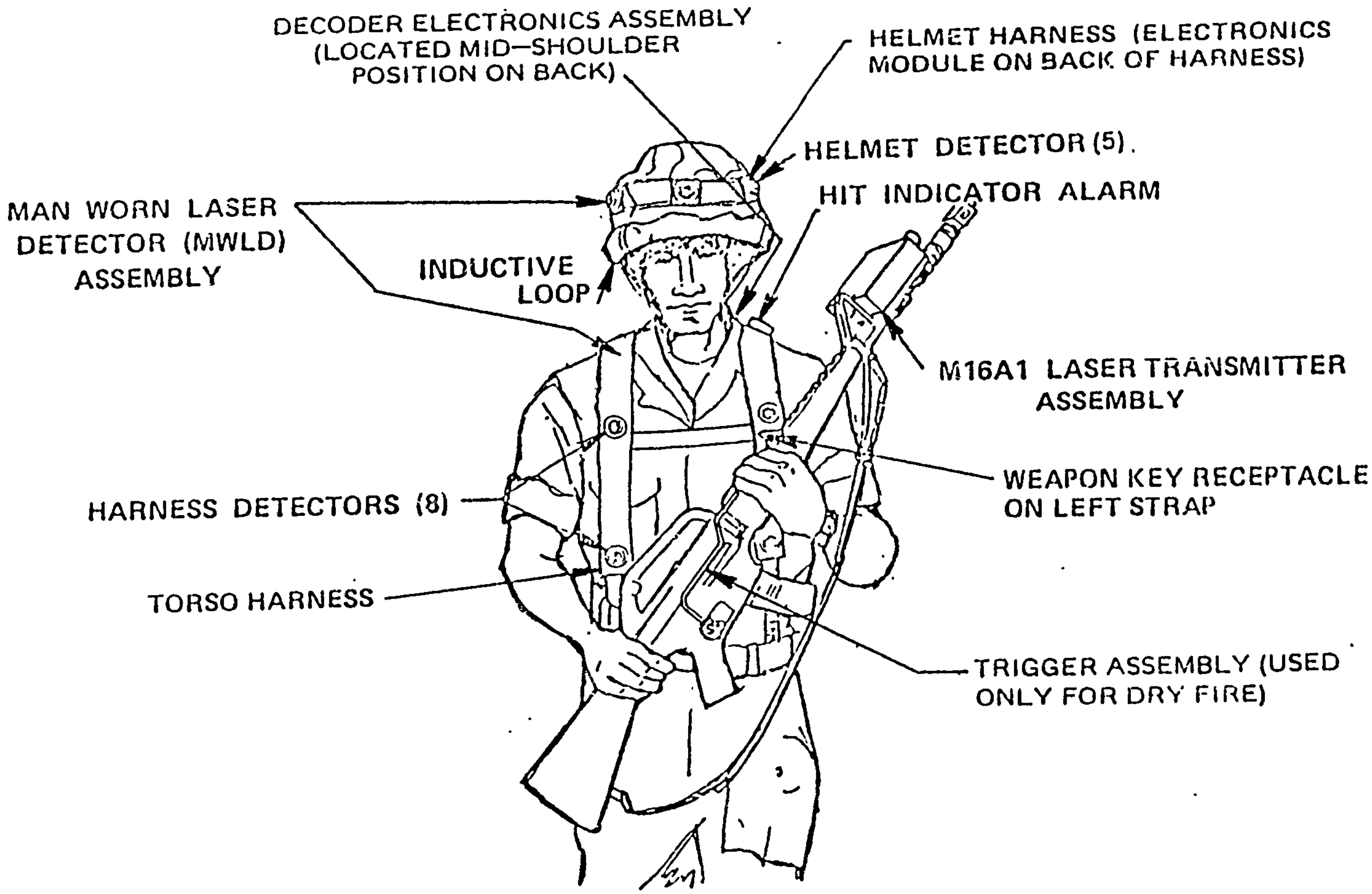

Figure 4-89. Hit Indicator Location - MWLD

Vehicle crewman can determine the type of weapon that hit or killed their vehicle by turning the selector switch on the Control Console or Control Indicator to HIT/KILL WEP IDENT and pressing the PRESS TO READ button. An illuminated number will appear in the display window. This number can be identified to a weapon or weapon class by finding the number on a casualty assessment card provided to the vehicle crew. An assessment card is depicted in figure 4-63

4.9 WEAPON KEY/CONTROLLER KEY DESCRIPTION AND OPERATION

Three keys, made of aluminum alloy, are used in the operation of MILES systems. Each of the three keys is configured differently and is of a different color. The keys are designed to prevent incorrect insertion and to preclude the key from falling out of the guide during operation. Figure 4-90 shows the difference in physical configuration of the keys. It also shows a typical independent transmitter and its weapon key receptacle.

4.9.1 KEY DESCRIPTIONS AND FUNCTIONS

The keys and their functions are summarized below:

a. Weapon Key - Yellow (Man System). This key is used with the following systems or assemblies:

   1. M16A1 Rifle System - Weapon enable/disable
   2. M60 Machine Gun System - Weapon enable/disable
   3. Man Worn Laser Detection Assembly - Alarm disable
   4. DRAGON Missile - Weapon enable/disable

   None of the above weapon transmitters will operate without the weapon key installed. The VIPER transmitter will operate without a weapon key, however.

b. Weapon Key - Orange (Vehicle Systems) This key is used with the following systems or assemblies:

   1. M113 APC System
      - M2 Machine Gun Assembly - Weapon enable/disable
      - Control Indicator Assembly - Alarm disable
   2. M60A1/A3 Tank System
      - M85 Machine Gun Assembly - Weapon enable/disable
      - Loaders Control Assembly - Alarm disable

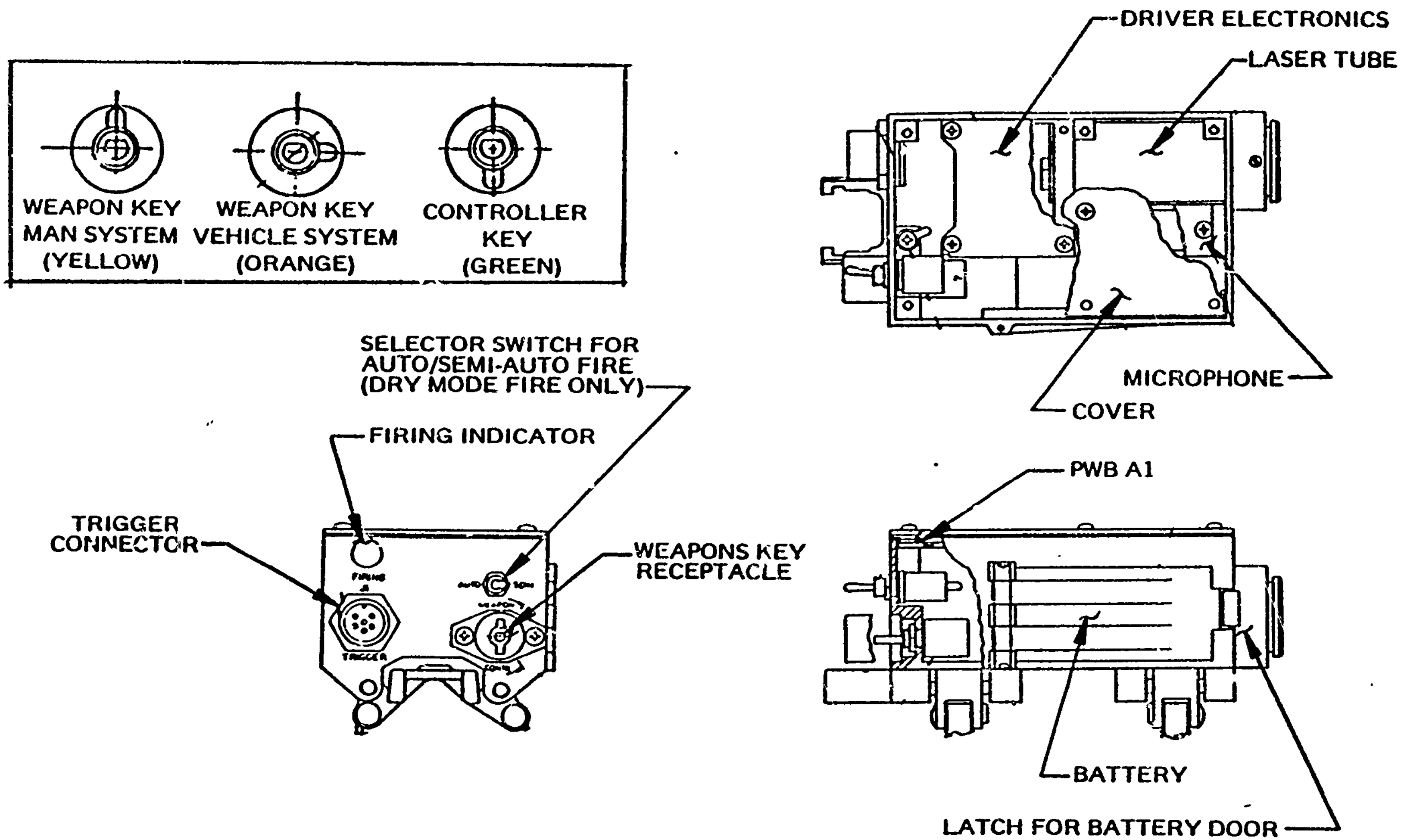

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Figure 4-90. Small Weapons Laser Transmitter and Weapon Key Configurations

c. Controller Key - Green Plastic. The controller key is attached to the lanyard of the Controller Gun (see figure 4-91) and is used with all of the above listed systems. The only exceptions where the controller key is not used or needed are as follows:

1. M16 rifle in blank fire mode.
2. M60, M2, and M85 machine guns in blank fire mode.

The basic uses of the controller key are to:

a. Enable (turn on) transmitters in the dry fire mode and supply them with a basic load of ammunition.

b. Enable dependent transmitters (via the control console) and supply them with a basic load of ammunition.

c. Reset both the MWLD and CVLD so that they are restored from a *killed* or *standby* condition to an active state.

d. Run special tests with laser transmitters.

e. Set laser transmitter for ATWESS or Dry Fire modes.

4.9.2 INDEPENDENT TRANSMITTERS - DRY FIRE MODE

The controller key is required to enable an independent transmitter (M16, M60, M2, M85, VIPER, and DRAGON) and supply it with ammunition. The controller key is inserted into the weapon key receptacle on the laser transmitter. For the TOW, the Controller key receptacle is located on the MGS Simulator. For the M16, M60, M2, or M85, the key is turned to the Controller position. The controller key is then rotated to its initial position and removed. For the DRAGON, VIPER or TOW, the controller key is inserted and rotated to the SET position, then rotated to either DRY FIRE or ATWESS and the key is then removed. Figure 4-92 shows the decal configurations for the VIPER and DRAGON which help to explain the weapon key/controller key operation. The weapon key (yellow for the M16, M60, and DRAGON; orange for the M2 and M85) is then inserted and turned to ON. The weapon is now ready to fire in the dry fire or ATWESS mode. There are no weapon keys for the VIPER or TOW transmitters and they are ready to fire after the controller key operation. *

Basic ammunition supply, firing rate, and burst limits are as follows:

a. M16 - 210 rounds, 678 rounds per minute, 30 rounds per sustained squeeze

b. M60 - 600 rounds, 678 rounds per minute, 200 rounds per sustained squeeze

c. M2 and M85 - 1200 rounds, 678 rounds per minute, 200 rounds per sustained squeeze

d. DRAGON - 4 rounds, 4 rounds per minute

65497

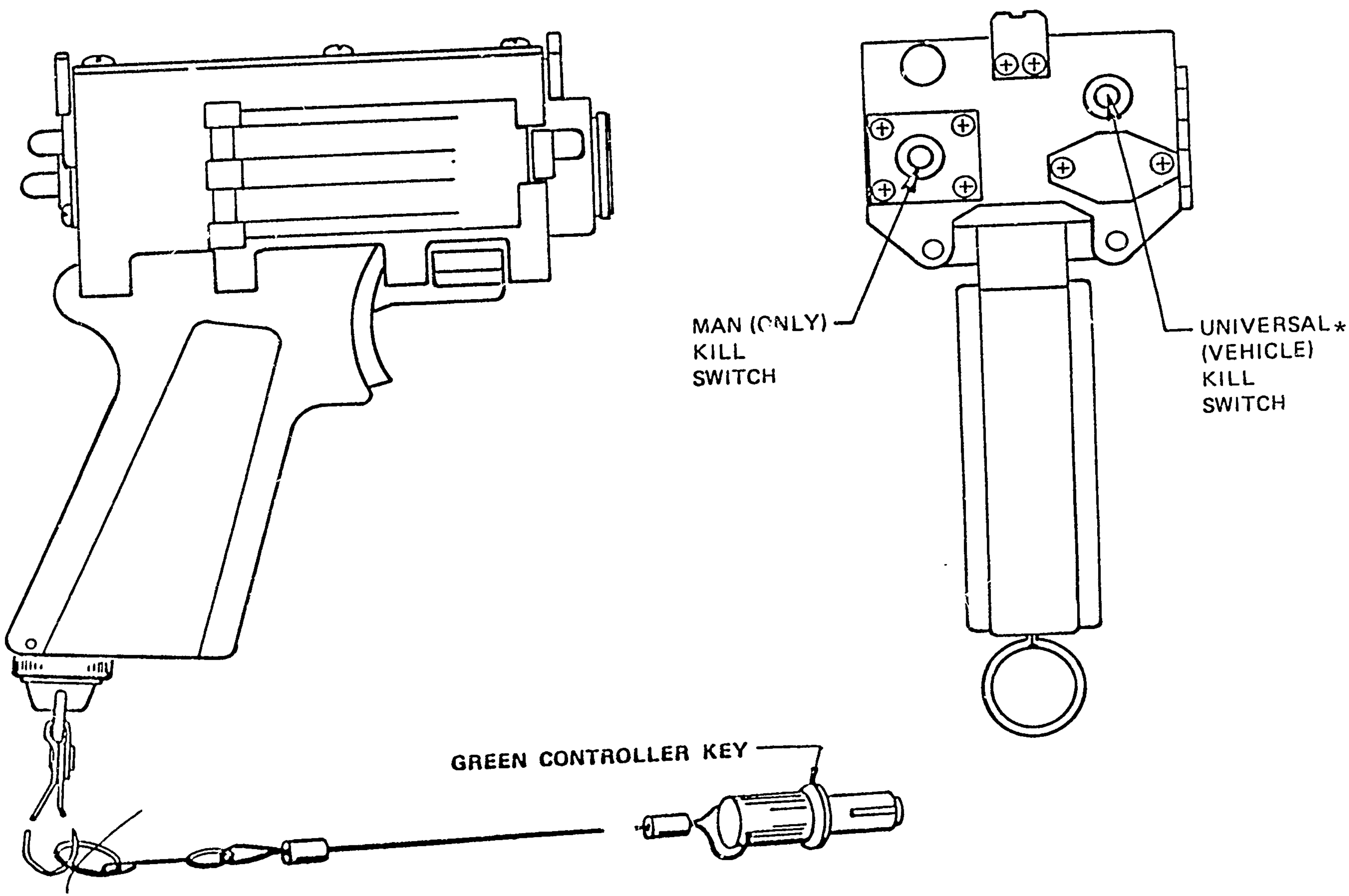
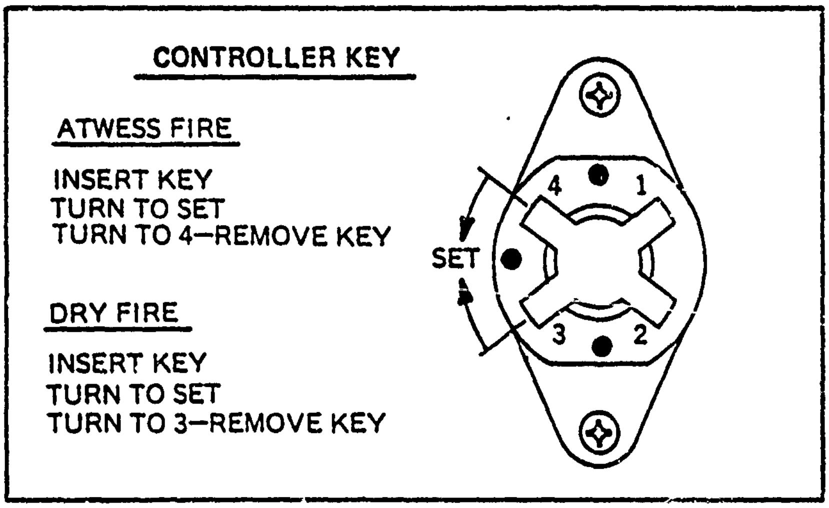
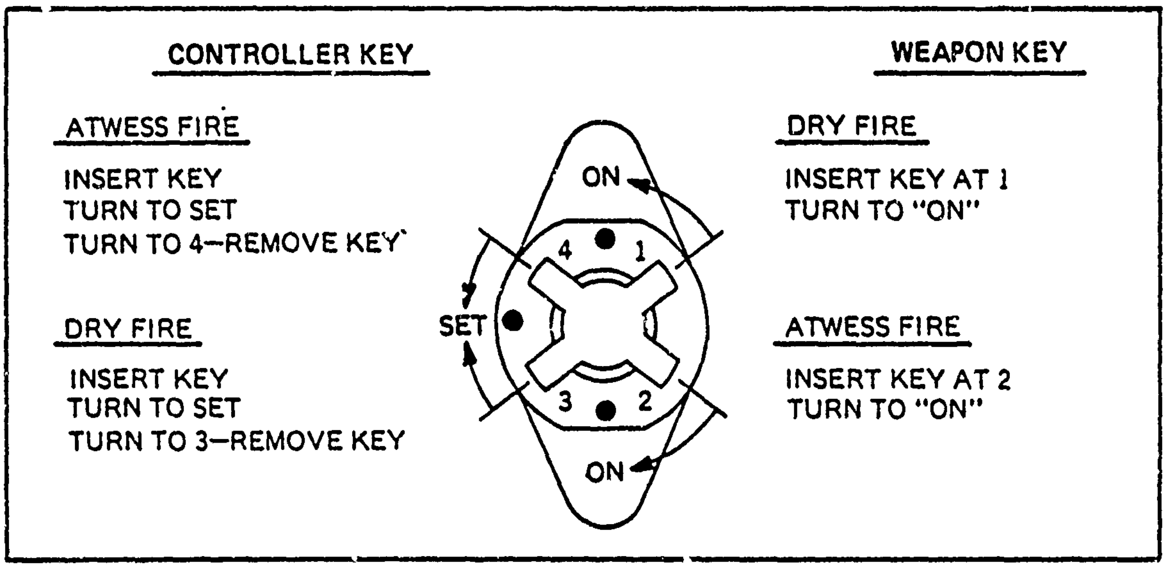


Figure 4-91. Controller Gun Outline Drawing



VIPER DECAL
CONTROLLER KEY OPERATION
(NO WEAPON KEY FOR VIPER)



DRAGON DECAL

Figure 4-92. Dragon and Viper Decals Weapon Key/Controller Key Operation

61107

e. VIPER - 4 rounds, 6 rounds per minute

f. TOW - 12 rounds, 4 rounds per minute

For the M16 rifle and the M60, M2, and M85 machine gun laser transmitters there is no indicator in the dry fire mode to show rounds remaining. Each of these weapons has a firing indicator light which illuminates each time a laser round is fired. When all ammunition is expended, the laser will cease to fire and the indicator light will not illuminate.

The DRAGON, VIPER and TOW, when used in the ATWESS mode, are dependent upon ATWESS and the transmitters will not fire unless a live ATWESS cartridge is properly inserted. A closure switch on the ATWESS cartridge allows firing of the laser transmitter when the fuse is intact. Firing of the ATWESS severs the fuse and the transmitter cannot fire again until a new ATWESS cartridge is loaded in the weapon.

The DRAGON, VIPER and TOW each have rounds counters than can be read by pushing a button. the number observed in the window is the total rounds remaining. A "00" indicates that all ammunition is expended. For the TOW, the rounds count button and display window are located on the MGS Simulator which plugs into the traverse unit coil cord.

4.9.3 DEPENDENT TRANSMITTERS

The controller key is required to enable the three dependent transmitters and to restore their basic ammunition loads. This is accomplished by inserting the controller key in the weapon key receptacle on the control console or control indicator (see figures 4-56 and 4-57). The key is turned as shown for CONTROLLER then returned to the initial position and removed. All of the vehicles' dependent transmitters are now ready for action and have a basic load of ammunition.

The weapons, basic loads, and firing rates are as follows:

a. 105mm/Coax transmitter Assembly

1. 105mm - 63 rounds, 12 rounds per minute
2. Coax Machine Gun - 1800 rounds, 678 rounds per minute. There is no burst limit on the Coax Machine Gun.

b. 152mm/Coax/Shillelagh Transmitter Assembly

1. 152mm/M60A2 Tank - 33 rounds, 6 rounds per minute
2. 152mm/M551 AARV - 20 rounds, 6 rounds per minute

3. Coax Machine Gun - 1800 rounds, 678 rounds per minute. No burst limit.

4. Shillelagh/M60A2 Tank - 13 rounds, 4 rounds per minute

5. Shillelagh/M551 AARV - 9 rounds, 4 rounds per minute

The rounds remaining can be checked at the control console. This is done by turning the ROUNDS REMAINING switch to the weapon in question and pressing the PRESS TO READ switch. The remaining number of rounds appear as an illuminated number in the DISPLAY window. A "00" means all ammunition for that weapon has been expended.

4.9.4 MWLD AND CVLD Reset

4.9.4.1 MWLD

When the infantryman first checks out the MWLD for use and installs batteries in the torso harness, the kill indicator alarm will sound. This must be shut off with the controller key. The controller key is inserted into the weapon key receptacle on the left front strap of the harness, turned clockwise, then returned to the initial position and removed. the MWLD is now alive and ready for action. The weapon key could be used to silence the alarm, but upon removal of the key the alarm again sounds and the MWLD remains *killed*. When the infantryman is *killed* by an opposing MILES weapon, the alarm on his MWLD sounds continuously. His weapon key must be removed from the weapon and inserted into the weapon key receptacle on the harness, and rotated to shut off the alarm. The MWLD remains in the *killed* state until reset by the controller key. Also, weapon key insertion when MWLD has not yet been *killed* by an opposing MILES weapon will automatically *kill* the MWLD and the alarm will sound if the key is removed.

4.9.4.2 CVLD

When battery power is first applied in the vehicle systems, the vehicle systems go into a standby state which requires the controller key for initialization. The control console will indicate this by displaying the number "33" in all positions when the PRESS TO READ button is pressed. To clear this condition and ready the vehicle for action, the controller key is inserted into the weapon key receptacle on the control console, turned in the direction marked CONTROLLER then returned to its initial position and removed. The CVLD is now initialized and ready for action. (All dependent transmitters have also been reset and supplied with basic loads of ammunition by the above action.)

When the vehicle is *killed*, the dependent transmitters are all automatically disabled by the control console. The orange weapon key from the cupola machine gun (either M2 or M85 depending upon the vehicle) is removed and must be inserted into the weapon key receptacle of the control console and rotated to shut down the intercom alarm. The CVKI strobe light will continue flashing until reset by

the Controller. Removal of the weapon key from the gun disables it. The yellow weapon keys issued to the vehicle crew for use with their MWLD cannot be used for this function and cannot be inserted into the Control Console receptacle. The orange key, if used in the control console prior to a vehicle kill, will result in a self-kill. If the orange weapon key is removed, the intercom alarm will again be activated along with the CVKI strobe light.

To clear the killed condition of the vehicle, the weapon key must be removed and the controller key inserted, turned in the direction labeled CONTROLLER, returned to the initial position, and removed. The vehicle is then ready for action with all systems restored and resupplied with laser *ammunition.* Blank ammunition must be obtained for a full-up system. *

4.9.5 SPECIAL TESTS WITH LASER TRANSMITTERS

When it is desired to run special tests on independent weapon laser transmitters where it would be undesired to continue resupplying ammunition, the controller key can be used. With the controller key in and the weapon transmitter turned on, the weapon has unlimited laser ammunition. The rounds count will not be decremented, however, other functions, such as firing rates and burst limits, remain the same.

SECTION 5
SYSTEM TESTING

XEOS implemented a totally integrated MILES test program during the ED phase. This test program and its results are documented in the "Trainer Test Procedures and Results Report," Data Item A003 of the contract, and XEOS document No. 2350-23016 volumes I, II, III and IV.

The testing and test results were extensive and even a summary is beyond the scope of this document.

SECTION 6
RELIABILITY

The reliability requirements and the XEOS plan to achieve them on the MILES hardware were documented in the Trainer Reliability Program Plan, CDRL item D001, XEOS document No. 22640, dated 26 July 1976.

Reliability demonstrations were performed and the results documented in a "Reliability Demonstration Test Report," CDRL item D004 and XEOS document No. 2350-AD-143 and 2350-AD-170.

Table 6-1 is a summary showing the required MTBF for each unit and the estimated MTBF based on a reliability analysis.

Table 6-2 summarizes the reliability test requirements, and table 6-3 the test results. Details of the test results are in the Reliability Demonstration Test Reports.

Table 6-1. RELIABILITY MEAN-TIME-BETWEEN-FAILURE ANALYSIS STATUS

DESCRIPTION	CALCULATED OR ESTIMATED MTBF (HRS)	SPECIFIED MTBF (HRS)	MINIMUM ACCEPTABLE VALUE (MAV) MTBF (HRS)
1. MWLD	2321	1600	800
2. M-16 RIFLE XMTR	1821	1600	800
3. M-2 M. G. XMTR	1834	1600	800
4. M-85 M. G. XMTR	1834	1600	800
5. M-60 M. G. XMTR	1834	1600	800
6. VIPER MISSILE	1830	1600	800
7. DRAGON MISSILE	1801	1600	800
8. CONTROLLER GUN	1982	1600	800
9. FIELD TESTER	5070	800	400
10. VEHICLE SYSTEM CONSISTING OF:			
TOW/APC	532	700	350
M113/APC	648	700	350
M60 A1/A3	532	700	350
M551/AARV	539	700	350
M60 A2	529	700	350
DETECTOR, BELT SETS			
M113 APC = 6,187 hrs.			
M60 A1/A3 = 7,826 hrs.			
M551 =11,620 hrs.			
M60/A2 = 7,747 hrs.			
TOW/APC = 6,187 hrs.			
152 mm/SHIL/COAX XMTR	7286	---	---
105 mm/COAX XMTR	7782	---	---
TOW XMTR	13661	---	---
CVKI	11547	---	---
ASSY, LOADERS CONT	679	---	---
ASSY, CONT. IND.	766	---	---
11. ATWESS	1837 (RDS)	1900 (RDS)	950 (RDS)

Table 6-2. RELIABILITY DEMONSTRATION

TEST PLAN XX USED FOR ALL TRANSMITTERS
TEST PLAN XX1 USED FOR ALL OTHERS
(IN ACCORDANCE WITH MIL-STD-781B TEST PLAN)

DEVICE	QTY REQ	DEVICE TEST TIME (HRS)	CUM. TEST TIME HRS
Transmitters	26	---	6240
M16	13	167	----
M60	2	167	----
M2	3	167	----
M85	2	167	----
Dragon	1	167	----
Viper	2	167	----
Controller Gun	3	167	----
Detectors	16	---	2944
Field Tester	3	184	----
MWLD	13	184	----
Vehicle Systems	5	---	1288
TOW	1	258	----
152 mm/Shil/Coax	1	258	----
105 mm/Coax	3	258	----
ATWESS	2	---	3496 RDS

Table 6-3. RELIABILITY TEST RESULTS SUMMARY

TEST ITEM	S/N	Started Test	Comp. Test	Required Test Hrs.	Actual Test Hrs.	Anomaly
M16 XMTR	033	5/24	6/1	167	185	None
M16 XMTR	030	5/24	6/1	167	185	None
M16 XMTR	014	5/24	6/1	167	185	None
M16 XMTR	034	5/24	6/1	167	185	None
M16 XMTR	020	5/24	6/1	167	185	None
M16 XMTR	006	5/24	6/1	167	185	None
M16 XMTR	027	5/24	6/1	167	185	None
M16 XMTR	032	5/24	6/1	167	185	None
M16 XMTR	012	5/24	6/1	167	185	None
M16 XMTR	016	5/24	6/1	167	185	None
M16 XMTR	037	5/24	6/1	167	185	None
M60 XMTR	003	5/24	6/1	167	185	None
M2 XMTR	009	5/24	6/1	167	185	None
M2 XMTR	008	5/24	6/1	167	185	None
M2 XMTR	002	5/24	6/1	167	185	None
M85 XMTR	009	5/24	6/1	167	185	None
M85 XMTR	011	5/24	6/1	167	185	None
DRAGON XMTR	004	5/24	6/1	167	185	None
VIPER XMTR	012	5/24	6/1	167	185	None
VIPER XMTR	008	5/24	6/1	167	185	None
CONTROLLER GUN	004	5/24	6/1	167	185	None
CONTROLLER GUN	003	5/24	6/1	167	185	None
CONTROLLER GUN	007	5/24	6/1	167	185	None
TRANSMITTER TOTALS				3841	4255	

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

TEST ITEM	S/N	Started Test	Comp. Test	Required Test Hrs.	Actual Test Hrs.	Anomaly
FIELD TESTER	006	6/14	6/22	184	189	None
FIELD TESTER	010	6/14	6/22	184	189	None
FIELD TESTER	002	6/14	6/22	184	189	Yes**
MWLD SET 1	T018/H036*	5/24	6/1	184	185	None
MWLD SET 2	T016/H113	5/24	6/1	184	185	None
MWLD SET 3	T015/H041	5/24	6/1	184	185	None
MWLD SET 4	T015/H115	5/24	6/1	184	185	None
MWLD SET 5	T020/H037	5/24	6/1	184	185	None
MWLD SET 6	T058/H039	5/24	6/1	184	185	None
MWLD SET 7	T012/H038	5/24	6/1	184	185	None
MWLD SET 8	T021/H120	5/24	6/1	184	185	None
MWLD SET 9	T075/H007	5/24	6/1	184	185	None
MWLD SET 10	T105/H008	5/24	6/1	184	185	None
MWLD SET 11	T062/H035	5/24	6/1	184	185	None
MWLD SET 12	T093/H040	5/24	6/1	184	185	None
MWLD SET 13	T069/H009	5/24	6/1	184	185	None
DETECTOR TOTALS				2944	2960	

* T = Torso
H = Helmet

** See Book I Part I
Section 7.0 of
2350-AD-143

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

TEST ITEM	S/N	Started Test	Comp. Test	Required Test Hrs.	Actual Test Hrs.	Anomaly
LCA	006	5/24	6/5	258	284	None
LCA	024	5/24	6/5	258	284	None
LCA	012	5/24	6/5	258	284	None
LCA	014	5/24	6/5	258	284	None
LCA	017	5/24	6/5	258	284	None
APC BELT SET	001	5/24	6/5	258	284	None
CVKI	010	5/24	6/5	258	284	None
CVKI	006	5/24	6/5	258	284	None
CVKI	007	5/24	6/5	258	284	None
CVKI	009	5/24	6/5	258	284	None
CVKI	002	5/24	6/5	258	284	None
152 mm XMTR	001	5/24	6/5	258	284	None
TOW XMTR	002	5/24	6/5	258	284	Yes**
TOW XMTR	004	6/14	6/26	258	285	None
105 mm XMTR	013	5/24	6/5	258	284	None
105 mm XMTR	014	5/24	6/5	258	284	None
105 mm XMTR	002	5/24	6/15	258	284	None
M60 BELT SET	001	5/24	6/5	258	284	None
M60 BELT SET	002	5/24	6/5	258	284	None
M60 BELT SET	033	5/24	6/5	258	284	None
M551 BELT SET	011	5/24	6/5	258	284	None
VEHICLE SYSTEMS TOTAL				5160	5965	

** See Book I Part I Section 7.0 Par. 3. of 2350-AD-143

Retest

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

TEST ITEM	S/N	Started Test	Comp. Test	Required Rounds Fired	Actual Rounds Fired	Anomaly
M16 XMTR	075	5/26	7/5	5000	5166	Yes **
M16 XMTR	117	5/26	7/5	5000	5130	Yes **
M60 XMTR	007	5/26	7/5	22000	22682	Yes **
BLANK FIRE TOTALS				32000	32978	
11749562 SIMULATOR	023	5/2/79	5/31/79	3496	1256	Yes ***
11749562 SIMULATOR	030	5/2/79	5/31/79		2240 3496	Yes ***
11749380 CARTRIDGE	(LOT)	5/2/79	5/31/79		3496	Yes ***
ATWESS TOTALS					3496	

** See Book I Part II Section 7.0 of 2350-AD-143

*** See Book I Part II Section 7 and 8.0 of 2350-AD-170

SECTION 7
MAINTAINABILITY

The maintainability requirements and the XEOS plan to achieve them on the MILES hardware are documented in the Trainer Maintainability Program Plan, CDRL item D005, XEOS document No. 22644, issued 23 July 1976 to NTEC.

Results of the Maintainability Demonstration are documented in the "Trainer Maintainability Demonstration Test Report," CDRL item D008, XEOS document No. 2350-AD-148. Table 7-1 summarizes the test results.

Table 7-1. Maintainability Test Results Summary

	MTTR Required	MTTR Demonstrated*
Organizational Level Tasks	30 Min Max	4 Min, 13 Sec.
Intermediate Level Tasks	60 Min Max	27 Min, 58 Sec.

*MTTRs shown are an average of all MILES systems tested.

SECTION 8
EMI SUPPRESSION

For the ED program, an Electromagnetic Interference (EMI) Control Plan was written, CDRL item D00A and XEOS document No. 22646. The plan was a guideline for the ED design and testing.

Results of EMI testing of the MILES systems are documented in CDRL item A003 of the contract and XEOS document No. 2350-23016.

SECTION 9

WORST CASE ANALYSIS

Worst case analysis combines the worst tolerance variations of all circuit components. Statistically, the situation described by such cases is extremely unlikely. Worst case analysis, therefore, gives a highly prejudicial view of the ability of a system to perform adequately. The intention here, and the real value of such an analysis, is to demonstrate that even at the tolerance extremes, there is no catastrophic failure and that reasonable performance continues.

9.1 LASER OUTPUT ENERGY

Since all transmitters are calibrated at room temperature, we treat here effects only at the temperature extremes. Further, since the temperature compensation network is designed for all components having nominal temperature characteristics, we only address variations from the nominal temperature characteristics of the components.

Figure 9-1 gives the model and equations governing I_D, the laser peak drive current. Table 9-1 defines the parameters used in this model and equations. The following assumptions apply:

a. $E \ll V_c$ so errors in the E term may be neglected.

b. All carbon composition resistors have repeatable TCs and their variation over temperature, although significant, is repeatable to a high (±1 percent) precision. Therefore, they contribute to TC errors in the order of ±2 percent in I_D.

c. Thermistors are highly accurate and do not contribute more than ±1 percent to output current error.

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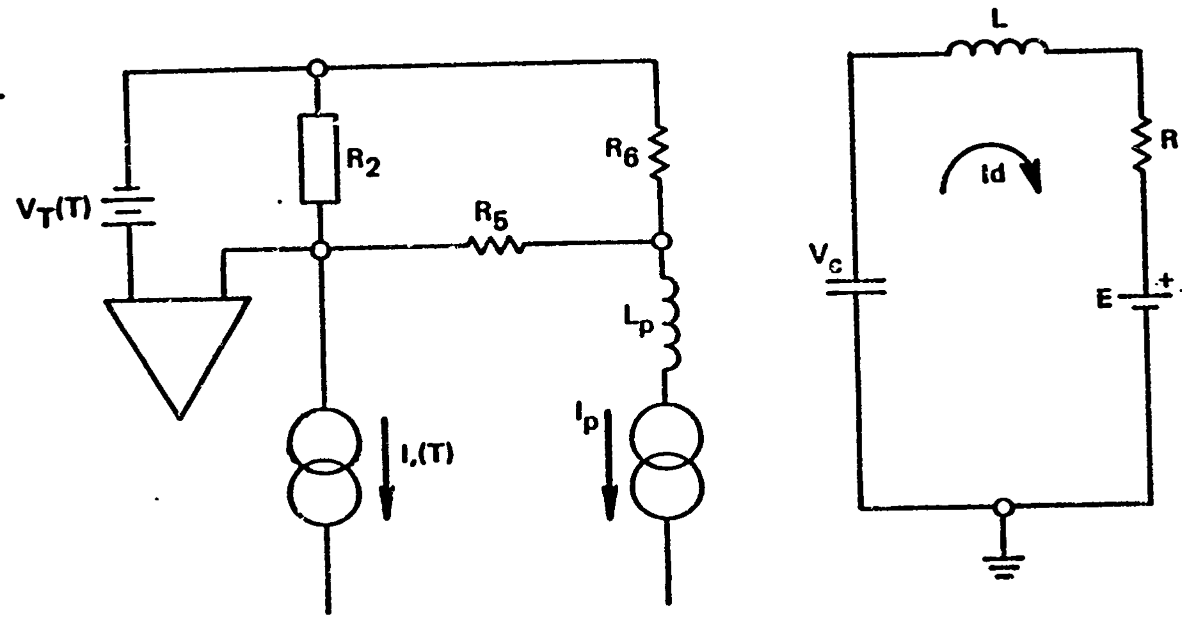
ED MILES PARAMETER VALUES

L	=	75×10^{-9} H
R	=	2 OHMS
R_6	=	2 TO 10 OHMS
R_5	=	11K
R_2	=	3K TO 28K
V_T (25°C) = 1.1V		
I_1 (25°C) = 100 μA		
L_p	=	1.25×10^{-3} H



(1) $I_p = 1/R_6 \left[V_T(1+R_5/R_2) - I_1 R_5\right]$

(2) $V_c = I_p \sqrt{L_p/C}$

(3) $I_D = \dfrac{(V_c - E)(1 - R^2C/4L)ee \exp\left[-RA/2Lw\right]}{wL}$

WHERE

$w = \sqrt{1/LC - R^2/4L^2}$

$A = \tan^{-1}\sqrt{(4L/R^2C) - 1}$

NOTE: IN PRACTICE, R IS NEGLIGIBLY SMALL AND EQUATION 3 REDUCES TO:
(sa
(3a) $Id \approx (V_c - E)\sqrt{C/L}$

Figure 9-1. Laser Output Energy Model

TABLE 9-1

DEFINITION OF PARAMETERS

E	=	laser and SCR voltage drop during current pulse
V_c	=	storage capacitor voltage
TC	=	temperature compensation
I_D	=	laser peak drive current
L	=	discharge loop inductance
L_p	=	transformer primary inductance
C	=	capacitance (of storage capacitor)
T	=	temperature
I_p	=	peak current in L_p
I_T	=	diode threshold current
K	=	slope efficiency
PW	=	pulsewidth
I_1	=	LSI input bias current
H	=	laser output energy

d. The sense resistors, being wire-wound from low temperature coefficient wire do not contribute to I_D error. This leaves, as the only other error sources in generating a TC'd laser drive current, unpredictable errors in L, Lp, and C.

Looking at figure 9-1, if we substitute Eq. 1 into Eq. 2, and Eq. 2 into Eq. 3, and neglect E, we obtain:

$$I_D \approx \sqrt{\frac{L_p}{L}} \cdot \frac{1}{R_6} \left[V_T \left(1+R_5/R_2\right) - I_1 R_5\right] \qquad (4)$$

Now, L_p, the transformer primary inductance, is specified to be within ±10 percent over the temperature range. This will, of course, yield ±5 percent in I_D if we assume that unit-to-unit unpredictability in L_p (CT) will indeed vary this much. (This is rather unlikely, but must be assumed in the worst case.)

The discharge loop inductance, L, is not controlled by specification, but has never been observed to vary significantly with temperature. Nevertheless, we shall assign a worst case variation of ±5 percent to it. This will yield a ±2.5 percent variation in drive current, but will produce a partially compensating ±2.5 percent change in pulsewidth. Change in pulsewidth will be tabulated in table 9-3.

Finally, we have unpredictable variations in C. They do not affect I_D, since C is transparent in the energy transfer from $1/2\ I_p^2/L_p$ to $1/2\ I_D^2\ L$. They do, however, affect pulsewidth.

$$H = 2\sqrt{L_p C} \cdot K \left\{ \sqrt{I_D^2 \cdot I_T^2} - I_T \sin^{-1} \left[(I_T/I_D) \right] \right\} \quad (5)$$

where:

K = diode slope efficiency
I_T = diode threshold current

Equation 5 shows that pulsewidth (and energy output) is proportional to the square root of C. The MIL Spec for ceramic capacitors allows a ±15 percent capacitance change at -55° and +125°C. We shall assume the MILES capacitors have worst case unpredictable capacitance variations of ±10 percent at the MILES temperature extremes. This reflects into a ±5 percent variation in pulsewidth (and energy output) as will be shown in table 9-3).

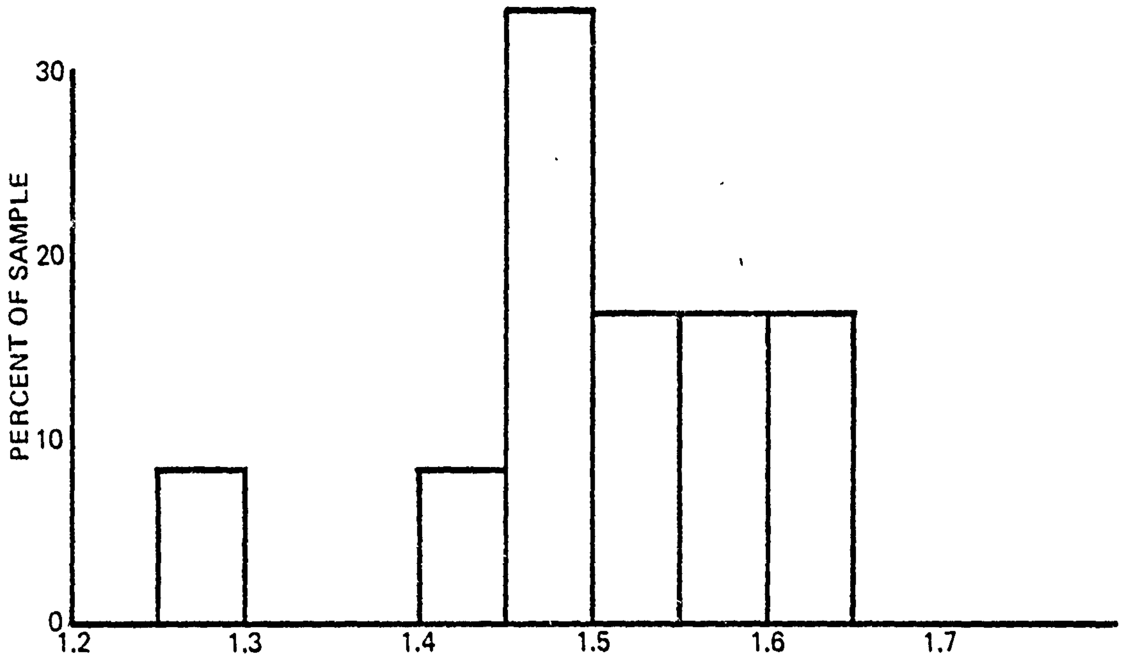
Unpredictability in I_D is now given by the following budget of errors:

	ΔI_D (%)
Carbon composition resistors	2.0
Thermistors	1.0
E (SCR and laser voltage drop)	-0-
Wire-wound resistors	-0-
L_p (transformer primary inductance)	5.0
L (discharge loop inductance)	2.5
C (storage capacitor)	-0-
	±10.5

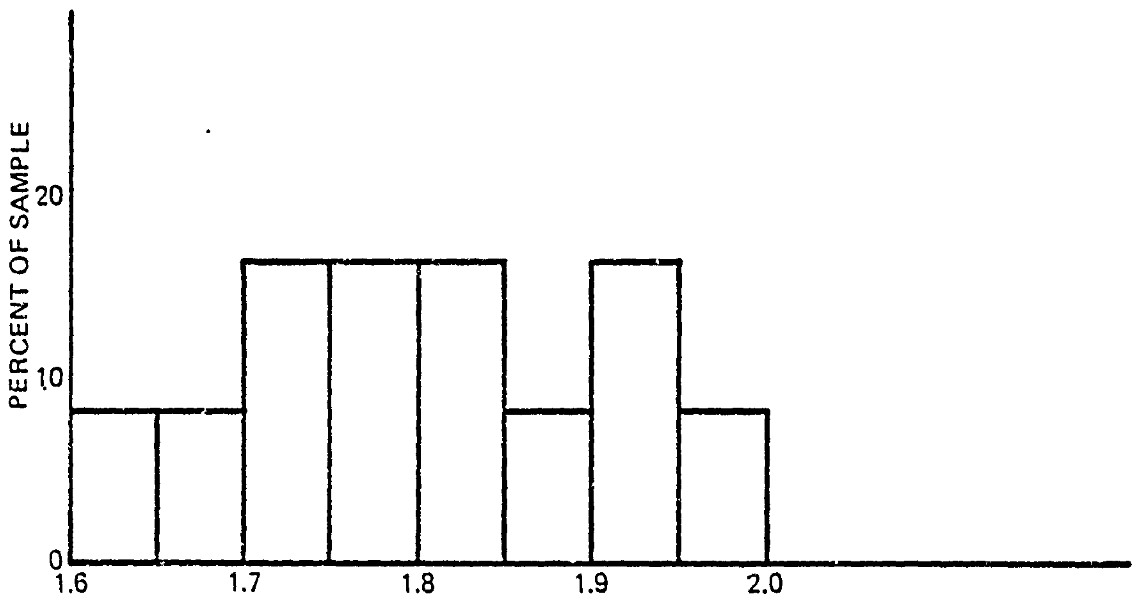
In the worst case, errors add together linearly as shown.

Finally, we must treat the effects of diode-to-diode variations. These effects are not present when 6-mil, single heterostructure diodes are used, since TC networks are designed for each individual diode. However, on multiheterostructure (MH) diodes, unit-to-unit variations are small enough so that we attempt to use a common TC network for each weapon type.

Figures 9-2 and 9-3 show variations in current drive compensation required over a sample of diodes. The variables presented here are the factors by which current must be increased or decreased at temperature extremes to maintain constant output energy. The temperatures for which we have data are -25°C and +75°C. The histograms show that the worst case distribution (6 mils @ -25°C) has a ±13.8 percent uncertainty. We shall use ±15 percent for worst case.



(a) $I_{25}/I_{.25}$ FOR CONSTANT OUTPUT POWER



(b) I_{75}/I_{25} FOR CONSTANT OUTPUT POWER

Figure 9-2. Current Drive Ratio Histograms, 6-Mil RCA Multi-Heterostructure Prototypes

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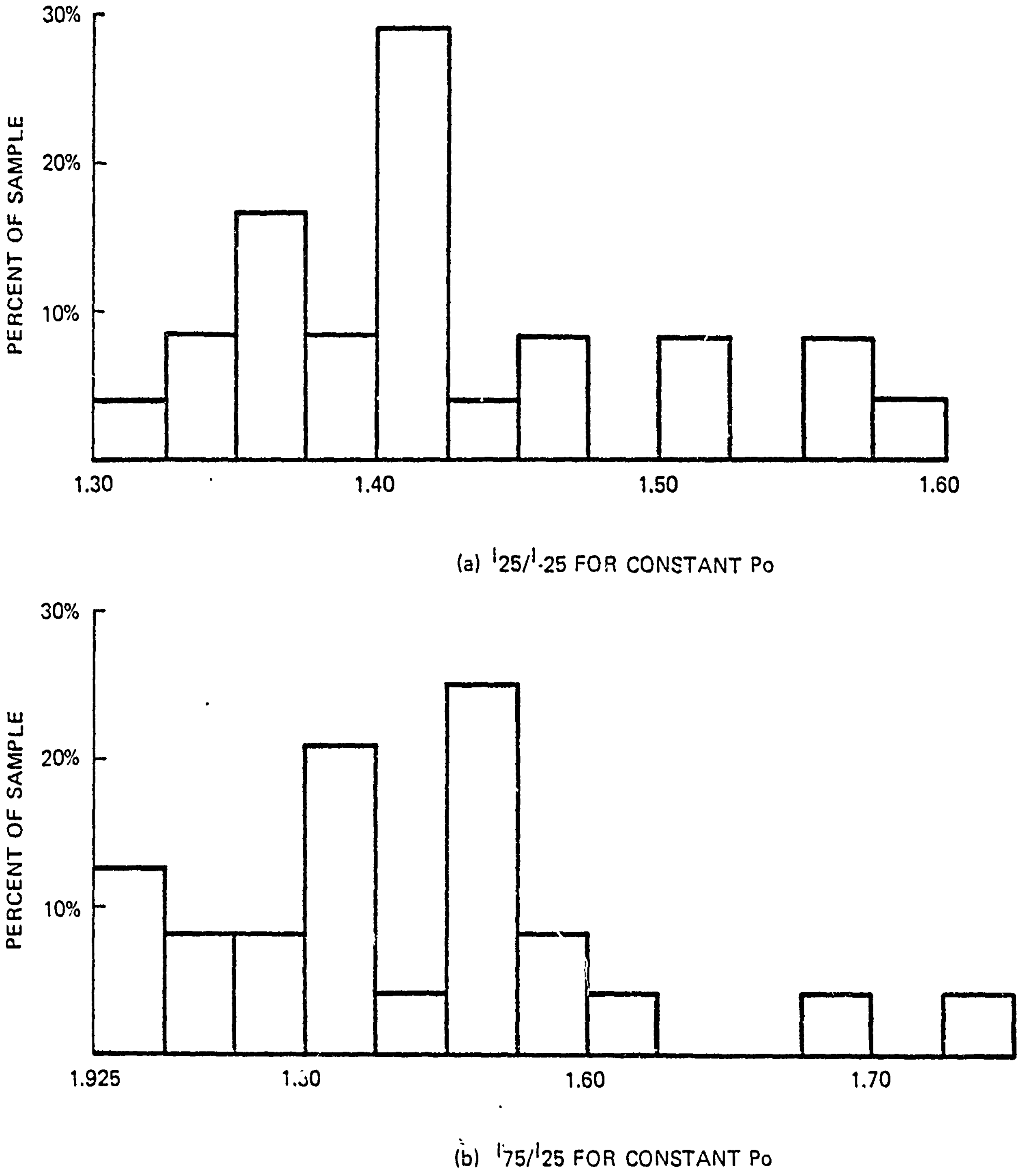

Figure 9-3. Current Drive Ratio Histograms, 3-Mil RCA Multi-Heterostructure Prototypes

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We must now allocate the ±15 percent between slope efficiency, K, and threshold, I_T. We assume that K and I_T uncertainties are both ±10 percent.

The expression in braces (from Eq. 5) is now evaluated at worst case extremes of I_T and I_D for a unit operating as close to threshold as is allowed on ED MILES: $I_D/I_T = 1.4$. Table 9-2 presents the results.

TABLE 9-2

OUTPUT VARIATIONS DUE TO CHANGES IN I_T AND I_D

Condition	I_T	I_D	{*}	{*} Normalized
I_T+10%; I_D-10%	7.7	9	0.48	0.30
Nominal	7.0	10	1.58	1.00
I_T-10%; I_D+10%	6.4	11	2.86	1.81

*{from Eq. 5}

Table 9-3 now summarizes error sources and presents the total worst case laser output error at temperature extremes.

TABLE 9-3

LASER OUTPUT ENERGY
ERROR SUMMARY

Variation in drive current, I_D	±10.5%	
Variation in threshold current, I_T	±10%	
Variation in output energy due to ΔI_D and ΔI_T (from table 9-2)		{+81%, -70%}
Variation in PW due to C	±5%	
Variation in PW due to L**	±2.5%	
Total output energy variation due to Δ PW		±5%
Variation in output energy due to slope efficiency variations		±10%
Total possible variation in output energy		{+100.4%, - 73.7%}

**The variation in PW due to L always partially compensates for variation in peak current.

Table 9-3 indicates that the low output energy may, in the worst case, drop to one-fourth its nominal value, thus halving the system range and beam size at a temperature extreme. However, it should be remembered that it is extremely unlikely that all the necessary conditions would occur simultaneously to cause this event to happen.

9.2 REGULATORS

Tables 9-4 and 9-5 give typical values for output voltages of the two voltage regulators in MILES. Tolerances are also shown. Data are measured, and tolerances are the 3 δ values fron Interdesign, the monochip manufacturer.

TABLE 9-4

LOOP RECEIVER-HORN DRIVER REGULATOR VOLTAGE

		Battery Voltage			
		+6V	+9V	+12V	
	$+75^{o}$	3.56	3.60	3.64	
Temp	$+25^{o}$	4.26	4.30	4.34	±5% Mfg. tolerance on monochip 3 δ values.
	-31^{o}	5.04	5.09	5.14	

Regulation: 0.1 to 2.0 mA ≈ -90 mV

TABLE 9-5

LASER DRIVER INTERFACE REGULATOR VOLTAGE

		Battery Voltage			
		+6.8V	+9V	+12V	
PIN	$+75^{o}$	3.75	3.79	3.83	
14	$+25^{o}$	4.47	4.51	4.55	±10%
(Hi Cur)	-31^{o}	5.27	5.32	5.37	

Regulation: 0.0 to 40 mA = -7 mV

		Battery Voltage			
		+6.8V	+9V	+12V	
PIN	$+75^{o}$	4.38	4.42	4.46	
1	$+25^{o}$	5.10	5.14	5.19	±10%
(Lo Cur)	-31^{o}	5.90	5.95	6.0	

Regulation: 0.0 to 40 mA on pin 14 = +0.2V

The LRHD (Loop Receiver Horn Driver) regulator is used in the MWLD to power the CMOS LSI decoder, which requires a voltage range of 3 to 6.0V The worst case low voltage occurs at end of battery life and at $75^{\circ}C$ where the voltage is 0.95 x 3.56 - 0.09V = 3.114V which is safe. Worst case high voltage is at a 12V battery voltage and $-31^{\circ}C$ where the voltage is 1.05 x 5.14V = 5.397V, again, a safe value.

The LDI (Laser Driver Interface) regulator is used in all independent transmitters and in the LCA/CIA. Its most demanding load is the 1802 microprocessor, which requires 3.5V to 6.0V.

The microprocessor is driven by different regulator outputs according to the high temperature extreme it will be exposed to. Weapons exposed to blank fire heating (M16, M60, M85, M2) have their 1802s connected to pin 1, the low current, high voltage pin. Weapons not exposed to this environment, but containing displays requiring high current, are configured using the high current low voltage output, pin 14. Data were taken only at $+75^{\circ}C$, so we must interpolate to obtain pin 14 data at $+65^{\circ}C$. Linear interpolation yields a typical output voltage of 3.89V for pin 14 at $+65^{\circ}C$ and a battery voltage of 6.8V. Applying a factor of 0.9 for the $\pm 10\%$ tolerance yields a worst case microprocessor voltage of 3.5V, just meeting the worst case microprocessor requirement.

In blank fire heated transmitters using pin 1 at $75^{\circ}C$, we have a worst case low voltage of 0.9 x 4.38V = 3.942V, again, sufficient for the microprocessor. Worst case high voltage will occur on pin 1 at $-31^{\circ}C$ and 12V battery voltage. That voltage is 1.1 x 6.6 + 0.2 = 5.8V. (The voltage at pin 1 increases as load is applied to pin 14 owing to the fact that pin 1 is a control voltage which is automatically raised to account for increased load on pin 14.)

9.3 RECEIVER SENSITIVITY

Table 9-6 presents energy-to-threshold data measured on ED production units. The most sensitive parameter in MILES signal detection is the fraction of detectors exposed. If only one detector is exposed, all the energy must be captured by it, and a high exposure in ergs/cm^2 is required. If all are exposed, then the effective aperture is increased, and a lower exposure will trigger the system.

TABLE 9-6

TYPICAL THRESHOLD ENERGY IN μergs

			Battery Voltage			
			+6.8V	+9V	+12V	
		$+65^\circ$	29.0	28.0	27.0	
	Temp	$+25^\circ$	26.0	25.0	24.0	±25%
8 Detectors		-35°	22.0	21.5	21.0	

			Battery Voltage			
			+6.8V	+9V	+11V	
		$+65^\circ$	23.0	22.0	21.0	
	Temp	$+25^\circ$	21.0		19.0	±25%
5 Detectors		-35°	18.0		17.5	

a. Most sensitive - An eight-detector belt, at the low end of the ±25% tolerance, with all eight detectors receiving signal, at 12V and -25°C.

$^*\underline{E_x} = 21 \times 0.75/8 = 1.97$ μergs/cm^2

b. Least sensitive - An eight-detector belt at the high end of the ±25% tolerance, with only one detector exposed, at 6.5V and 65°C.

$\overline{E_x} = (29.0)(1.25)/1 = 36.25$ μergs/cm^2

This difference in sensitivity as detectors are covered or exposed is used to advantage.

$^*E_x$ = exposure, μergs/cm^2

MILES belts are configured on vehicles and men in order to use variations in number of detectors to tailor hit probabilities to target profile. A more useful calculation is to determine, for a given number of detectors exposed, what the worst case variation in threshold exposure is.

The eight-detector belt has slightly more variation with battery and temperature:

Most sensitive +12V, $-35^{o}C$, -25% => 15.75 μergs
Least sensitive +6.8V, $+65^{o}C$, +25% => 36.25 μergs

Thus the difference between the two extreme (3 δ) units is slightly over a factor of two.

9.4 CONCLUSIONS

The foregoing worst case analyses indicate that even with extreme combinations of tolerances, the MILES system will function and not suffer catastrophic failure.

The most variable feature is the laser output energy which, as shown in table 9-3, may vary from one-fourth to twice the nominal value. This situation may be improved significantly if the nominal ratio of peak diode current-to-threshold current is raised to about two to one as shown in table 9-7. This change is contemplated as a future product improvement wherein laser output at a nominal drive current will be standardized by selecting neutral density filters to be associated with each laser.

Table 9-7 should be contrasted with table 9-2. Rather than the original worst case variations of +81 percent and -70 percent, the variations are now reduced to +35 percent and -42 percent. This reduction results from using a nominal ratio of I_D/I_T of 2.

TABLE 9-7

OUTPUT VARIATIONS DUE TO CHANGES IN I_T AND I_D
FOR I_T/I_D = 2.0 NOMINAL

	I_T	I_D	{ * }	{ * Normalized }
I_T+10%; I_D-10%	7.7	12.6	4.91	0.58
Nominal	7.0	14.0	8.46	1.00
I_T-10%; I_D+10%	6.3	15.4	11.40	1.35

* From Eq. 5

SECTION 10 *

FIELD SUPPORT EQUIPMENT

10.1 INTRODUCTION

This report describes the engineering design of the MILES Vehicle Test Set and the Small Arms Alignment Fixture. The Vehicle Test Set is used to troubleshoot and fault isolate MILES equipment used on vehicles and the Small Arms Alignment Fixture is used to boresight small arms MILES transmitters (specifically the M16A1 rifle and M60 machine gun) to the weapon sights.

10.1.1 VEHICLE TEST SET

The Vehicle Test Set is a small, portable support equipment item used to fault isolate MILES vehicle systems to the level of vehicle belt segments, control or indicator consoles, kill indicators, cables, and power supplies (vehicle power or MILES battery supplies). This device is designed to be carried to MILES-equipped vehicles in the field.

All power to operate the test set is received from the system under test, therefore, the test set contains no internal power. All gauges, switches, and input and output connectors are located on the front panel which is protected when in transit by a hinged, gasketed water resistant cover.

Analog displays mounted on the front panel are used to indicate belt noise levels and dc voltages. An audio indicator is used to indicate the presence of the combat vehicle kill indicator (CVKI) trigger signal from the vehicle's control console.

The test set may be used at any time vehicle equipment problems occur, but is primarily used for troubleshooting during initial installation of MILES equipment on vehicles. In addition, the test set may be used to check the condition of 6 volt and 9 volt batteries used in all MILES systems including those used in the small arms systems.

10.1.2 SMALL ARMS ALIGNMENT FIXTURE

The Small Arms Alignment Fixture is an electronically operated device used to aid in boresighting the MILES laser transmitter to the sights of the M16A1 rifle and M60 machine gun. This procedure is conducted when a MILES laser transmitter is first attached to the weapon and at any other time that a soldier would normally be expected to adjust his sights.

Weapon sight alignment is performed at a standard range of 25 meters. The center of the front panel of the alignment fixture resembles a standard paper target used in the Army including the notched rectangular "bullseye." With the MILES transmitter attached to his weapon, a soldier aims and fires at the target. An array of receiving diodes located behind the target face receive the laser signal and calculate how far and the direction the laser signal was from the center. Numbers displayed on the front panel indicate the number of "clicks" and direction the soldier must adjust his sights in order to hit the center of the target.

Subsection 10.2 of this report provides a system analysis including a description of the training problem and technical approach. Subsection 10.3 contains the design approach, design considerations, and assumptions used in the design of these support items. Subsection 10.4 contains the quality assurance, reliability, and maintainability requirements.

10.2 SYSTEM ANALYSIS

10.2.1 VEHICLE TEST SET

If a MILES vehicle system does not operate properly, a number of fault possibilities exist, depending upon the symptoms. The problem could lie with a defective component, such as a malfunctioning detector belt segment, a faulty control or indicator console, an inoperative combat vehicle kill indicator (CVKI), or a low battery. A problem could also exist in the interconnecting cabling. Other fault possibilities include dirty connections or a defect in the vehicle's own electrical system.

The purpose of the Vehicle Test Set is to provide a means to quickly test the vehicle system in the field and to isolate the problem to a MILES component that can be repaired or replaced by the vehicle crew.

10.2.2 SMALL ARMS ALIGNMENT FIXTURE

Unlike the Vehicle Test Set, which is used only for troubleshooting, the Small Arms Alignment Fixture is typically used at the beginning of every exercise. Following initial installation of MILES transmitters on the M16A1 rifle and M60 machine gun, some means must be provided to adjust the sights on these weapons to the optical axis of the transmitter.

The path of the laser transmitter signal differs from the trajectory of a live round fired from the same weapon because of two reasons:

a. The path of the transmitter signal is straight rather than following a curved trajectory as would a live round.

b. The optical axis of the transmitter is offset from the center of the gun barrel by a small amount.

These two factors, therefore, cause the sight adjustments to be different than the soldier would normally have them set for firing live rounds, and the Small Arms Alignment Fixture provides the means to accurately and quickly perform the weapon sight adjustment.

In use, the alignment fixture is set up in the field and each soldier, in turn, fires his MILES-equipped weapon at the target on the front panel from a standard distance of 25 meters. An array of receiving detectors installed behind the target face register the location where the MILES laser beam hit the display and the internal microprocessor calculates the vector from the target center. This value is calculated in terms of the number of "clicks" and the direction the soldier must turn the adjustments on his weapon sights in order to bring the firing point to the center of the display.

These numbers are displayed on four electromagnetic displays located adjacent to the four sides of the target. When zeroes appear in all four displays, the target center was hit and no further weapon sight adjustment is necessary.

Because the number of weapon sight "clicks" differ between the M16A1 rifle and M60 machine gun, a switch on the front panel of the alignment fixture changes the operating mode for the weapon type being aligned.

10.3 DESIGN APPROACH

10.3.1 VEHICLE TEST SET

In arriving at a final configuration for the Vehicle Test Set, consideration was heavily affected by how the test set was to be used and who would be using and operating it. Since the Controller's Gun is needed to perform final vehicle system checkout and to initialize the system, the controller was designated to provide and to operate the test set. If a problem occurred requiring use of the test set, the controller, based on the symptom, would determine which tests to perform. He would connect the test set and with the help of the vehicle crew, check out the system. If a component was discovered to be faulty, the vehicle crew would be responsible for replacing it.

10.3.1.1 Physical Description

Since the test set must be carried to the vehicle, it must be small, lightweight, and be able to withstand the environmental conditions imposed on equipment used on the battlefield such as temperature, humidity, shock, dust, and vibration. The final physical configuration, as shown in figure 10.1, was the use of an aluminum case approximately 13.5 inches by 8 inches by 5.7 inches. Total unit weight is approximately 10 pounds.

The cover is attached to the case with a piano-type hinge and the inside of the cover has a hinged tray. A decal with operating instructions is attached to the face of the tray. The space below the tray

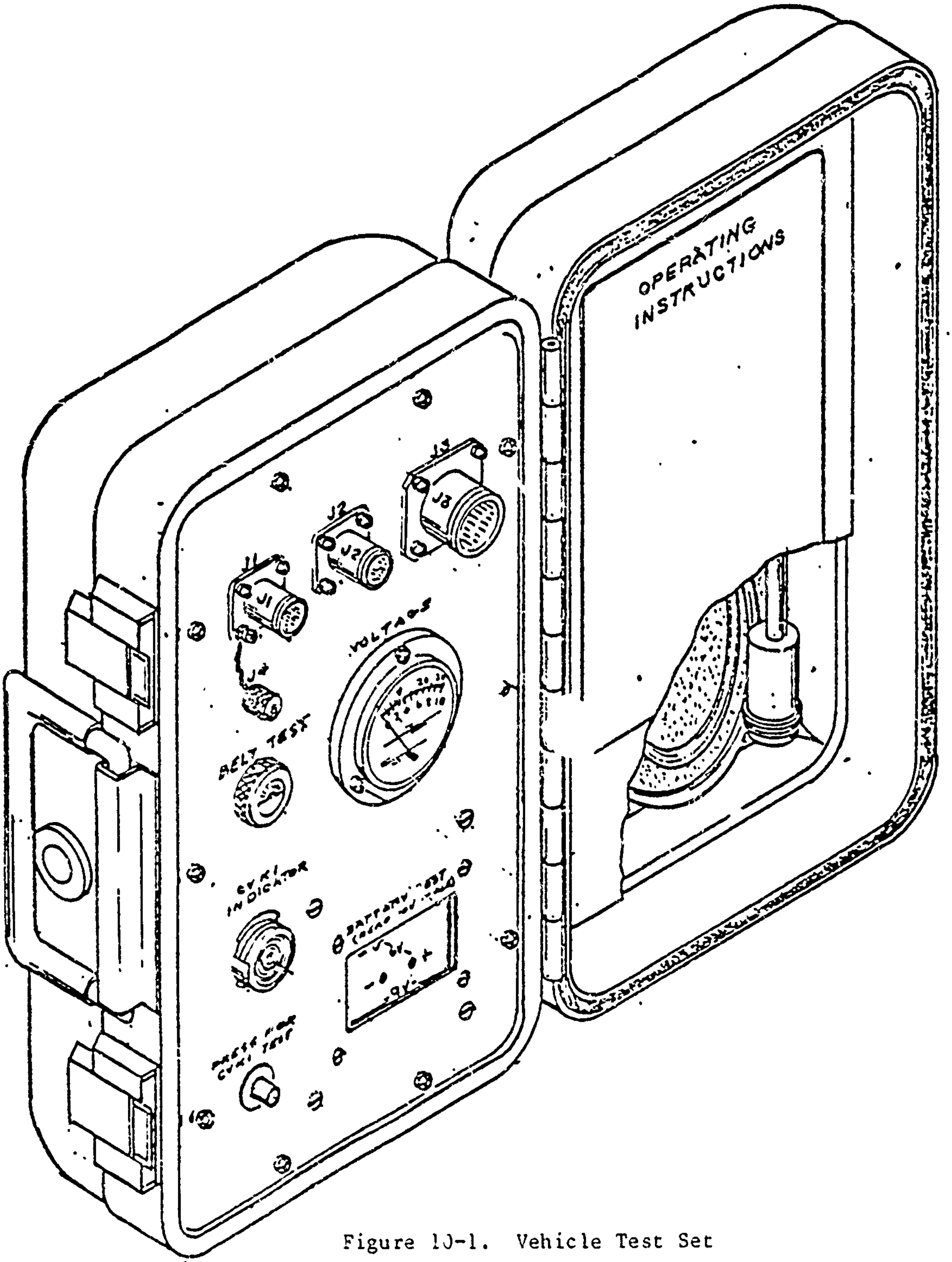

Figure 10-1. Vehicle Test Set

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is used to store the jumper cable which is used for certain trouble-shooting tests. The side opposite the hinge contains a carrying handle, two guarded, springloaded latches, one on either side of the handle, and a pressure relief valve. When the cover is closed and latched, the interior of the case is protected from external environmental conditions.

The front panel of the test set contains all of the meters, gauges, and input jacks. All of the electronic components are contained on one plug-in printed circuit board. Access to the board is gained by removing the ten screws from around the edge of the front panel and lifting the front panel from the case. The printed circuit board can then be removed by unplugging the four connectors from the board and removing the four screws holding the board to the case.

Because of the different size plugs and pin arrangements used in the MILES cables, it is not possible to insert a plug into the wrong jack on the test set. Since only dc voltages are present in the MILES system with a maximum value of less than 30 volts, one voltmeter with two scales (0 to 30 volts and 0 to 10 volts) is used to measure all voltages. The 0 to 10 volt scale is used when testing the condition of batteries using the front panel test pads.

10.3.1.2 Basic Operation

An analysis of MILES vehicle systems indicated that there are five major tasks required of the test set. These are:

a. Control Console/Indicator Check

To check operation of a vehicle control console or control indicator, the CVKI cable is disconnected from the console or indicator and attached to the appropriate jack on the test set. Battery voltages can then be read on the test

set voltmeter and false bit counts from the detector belts can be read on the test set bit count meter. Also, the CVKI and interconnecting cabling can be checked by depressing a push button on the test set and observing the CVKI for proper operation.

b. Belt Segment Check

To check one or more vehicle detector belt segments, the test set is connected in series with the detector belts. The test set may be connected at various locations around the vehicle depending on which belt or belts are to be checked. A jumper cable, normally stored behind a tray in the front cover, is provided for connecting into the system. Once connected to the vehicle belts the false bit count value is read on the bit count meter on the test set. The maximum allowable bit count value varies depending on how many belts are connected and whether the detectors are in the sun or shade. Instructions which accompany the test set list the various acceptable false bit count values.

c. CVKI Check

To check operation of the CVKI, the cable to the CVKI is disconnected and attached to a jack on the test set. An audio indicator on the test set sounds when detector belts are illuminated by the Controller Gun. This tone indicates the presence of a signal to the CVKI.

d. Battery Check

To check battery voltages, the battery terminals are pressed against test pads on the front panel of the test set and the voltage is read on a meter. Since only two types of batteries are used in the MILES system (6-volt lantern type and 9-volt transistor type), the test pads are so arranged to accept only these two types of batteries.

e. Trigger Signal Check

To ensure the vehicle control console is receiving the proper trigger signal voltage, the trigger cable to the console is connected to the test set, the appropriate trigger is pulled, and the voltage level of that signal is read on the Voltage meter on the 30V scale. Schematic diagrams for the Vehicle Test and its jumper cable are shown in figures 10-2 and 10-3.

f. Battery Box Check

To ensure that the MILES system is receiving the proper voltage level from the Battery Box, a jumper cable, normally stored behind a tray in front cover, is provided to connect to the Battery Box. Once connected to the Battery Box the voltage output will be displayed on the VOLTAGE meter.

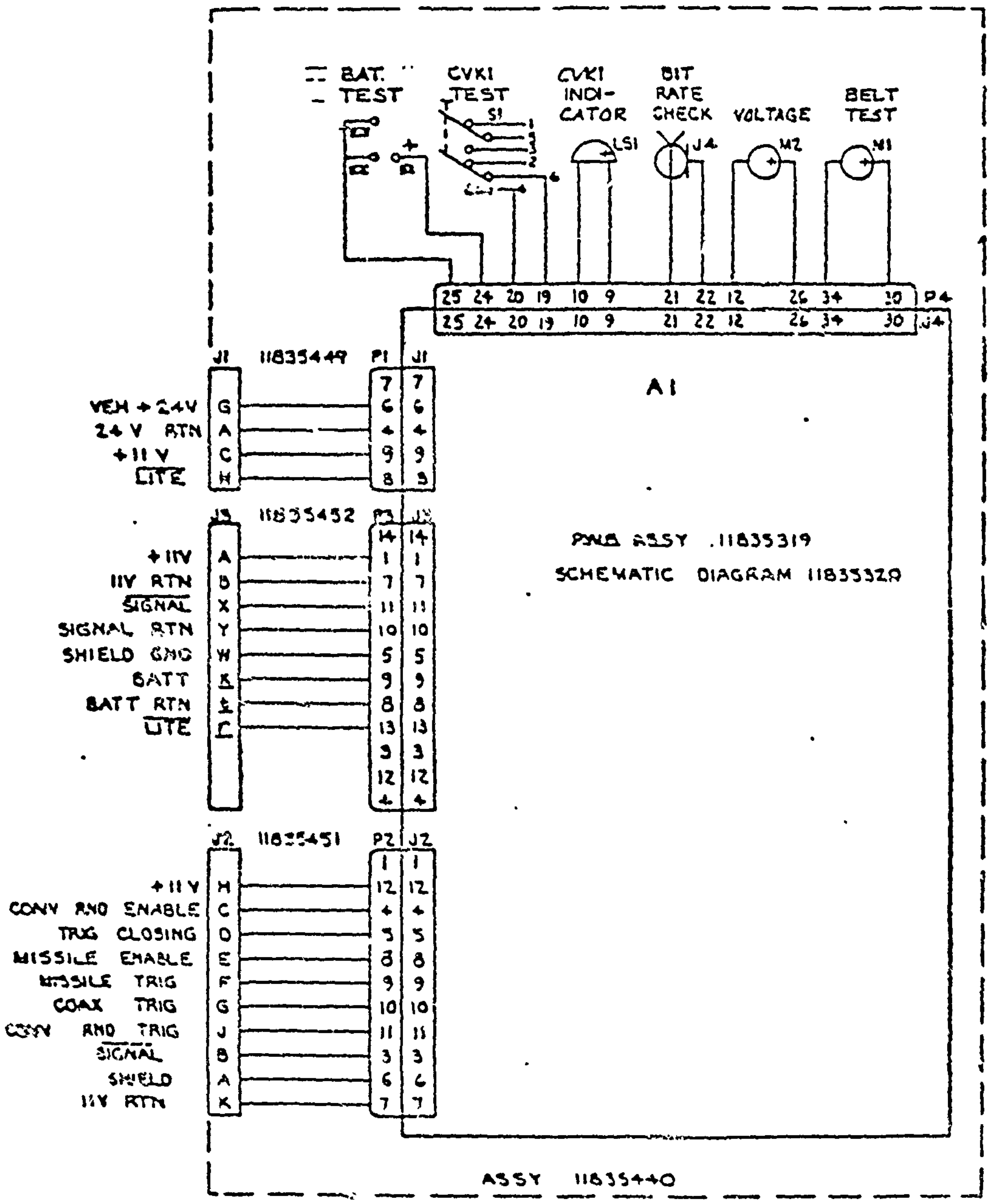

Figure 10-2. Vehicle Test Set Connection Diagram

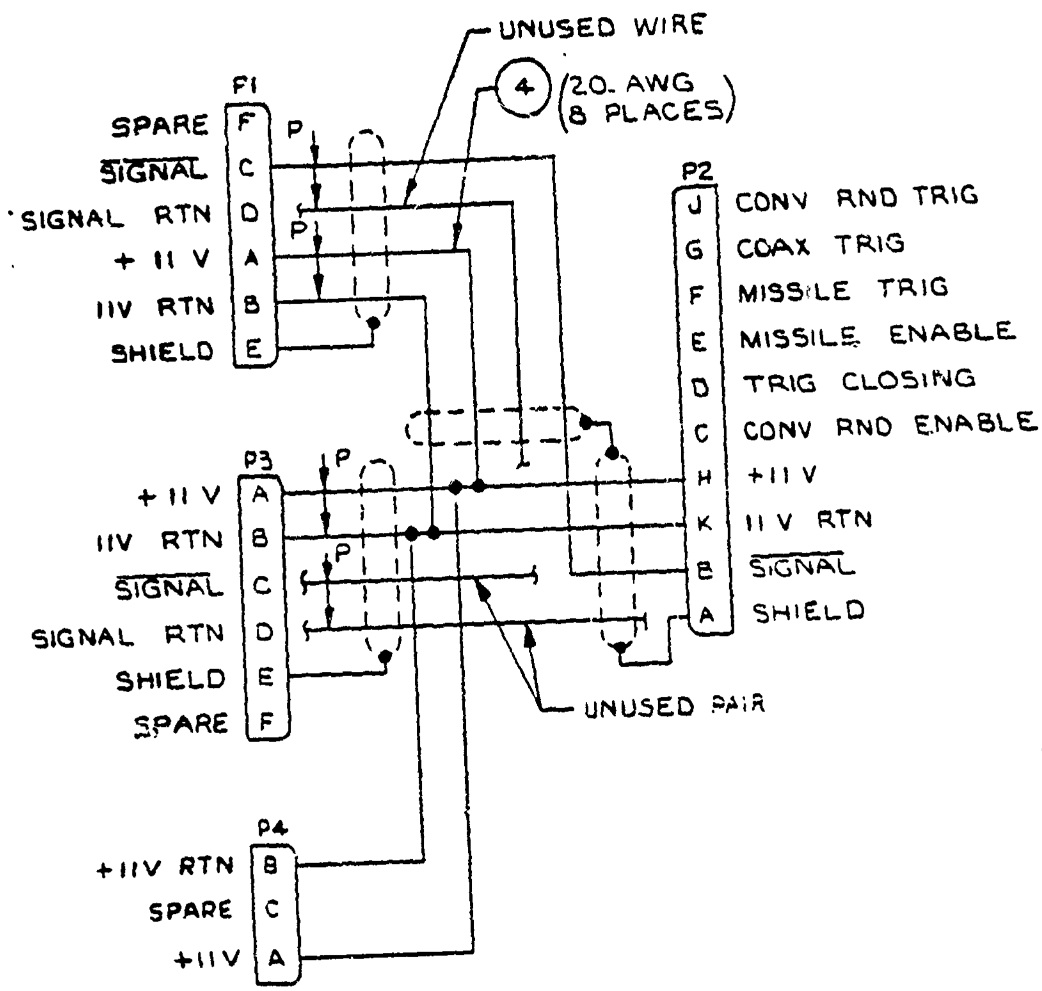

Figure 10-3. Jumper Cable, Schematic Diagram

10.3.1.3 Electrical Design

The printed circuit board for Vehicle Test Set (shown in figures 10-4) can be divided into two sections: (1) a bit rate integrator with meter interface; and (2) a meter interface for various voltage sources.

The bit rate integrator receives its inputs from BIT RATE CHECK (J4) (via connector J4, pin 21) or SIGNAL (via connector J2, pin 3 or connector J3, pin 11). These signals generate standard-sized pulses which are continuously integrated by a meter interface circuit. The meter interface circuit will condition the signal for compatibility with the BELT TEST meter (via connector J4, pin 30 and pin 34).

The meter interface circuit for the various voltage sources takes into consideration each different source. The impedance match and voltage division necessary for each source to make it compatible with the VOLTAGE meter is incorporated in the meter interface. VR1 protects the VOLTAGE meter by limiting meter current to approximately 120 percent of full scale. The VOLTAGE meter output is via connector J4, pin 26 and pin 12.

10.3.2 SMALL ARMS ALIGNMENT FIXTURE

10.3.2.1 Physical Description

The major physical design constraint was that the fixture must be packaged to withstand the environmental rigors of field use. The exterior dimensions of the fixture are 23 by 23 by 12 inches and weight is approximately 60 pounds. The case is constructed of aluminum and painted olive drab.

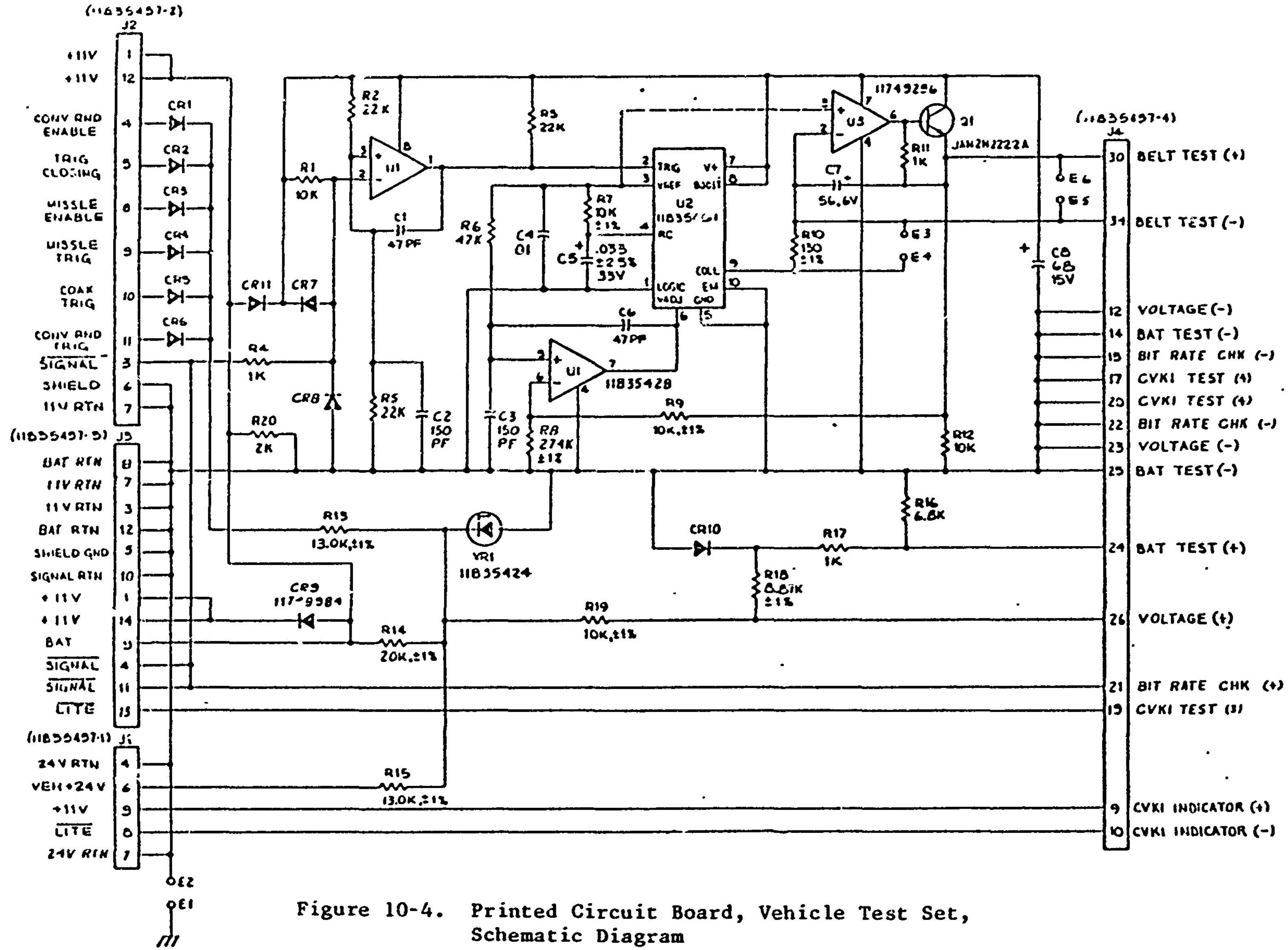

Figure 10-4. Printed Circuit Board, Vehicle Test Set, Schematic Diagram

To operate, the fixture was designed to be placed on the ground. As shown in figure 10-5, the bottom portion of the case remains flat on the ground and the top opens to a vertical position, similar to an open suitcase.

Since the vertical portion contains all of the operating components of the fixture, most of the weight is concentrated in this portion of the case. Therefore, to support and stabilize the heavy open portion of the case, a small stand is attached to the side that would normally face the ground when the case is open and two support braces lock with the case in the 90 degree open position.

Two handles, one on each side of the case swing open for use and have spring returns. Seven cam action positive locking latches are provided to secure and seal the case during transportation. A pressure relief valve is also installed on the side of the case.

All operating controls and displays are located on the front panel. Three hinged doors, also located on the front panel, provide access to the three 6-volt lantern type batteries which power the fixture.

To assure that the soldiers boresight their weapons at the proper distance of 25 meters, a cord 25 meters in length is stored inside a nylon bag located in the bottom portion of the case. The bag also contains an instruction card for the SAAF. There is adequate room within the bag to store 10 small arms trigger cable assemblies.

The front panel of the fixture contains an array of 144 high speed photodiodes. These diodes detect the laser beam and analog and digital processing circuitry intrepret the received signals to provide accurace beam positioning data. The diodes require a minimum laser engery coded signal of 0.1 erg over 1 cm^2 to react.

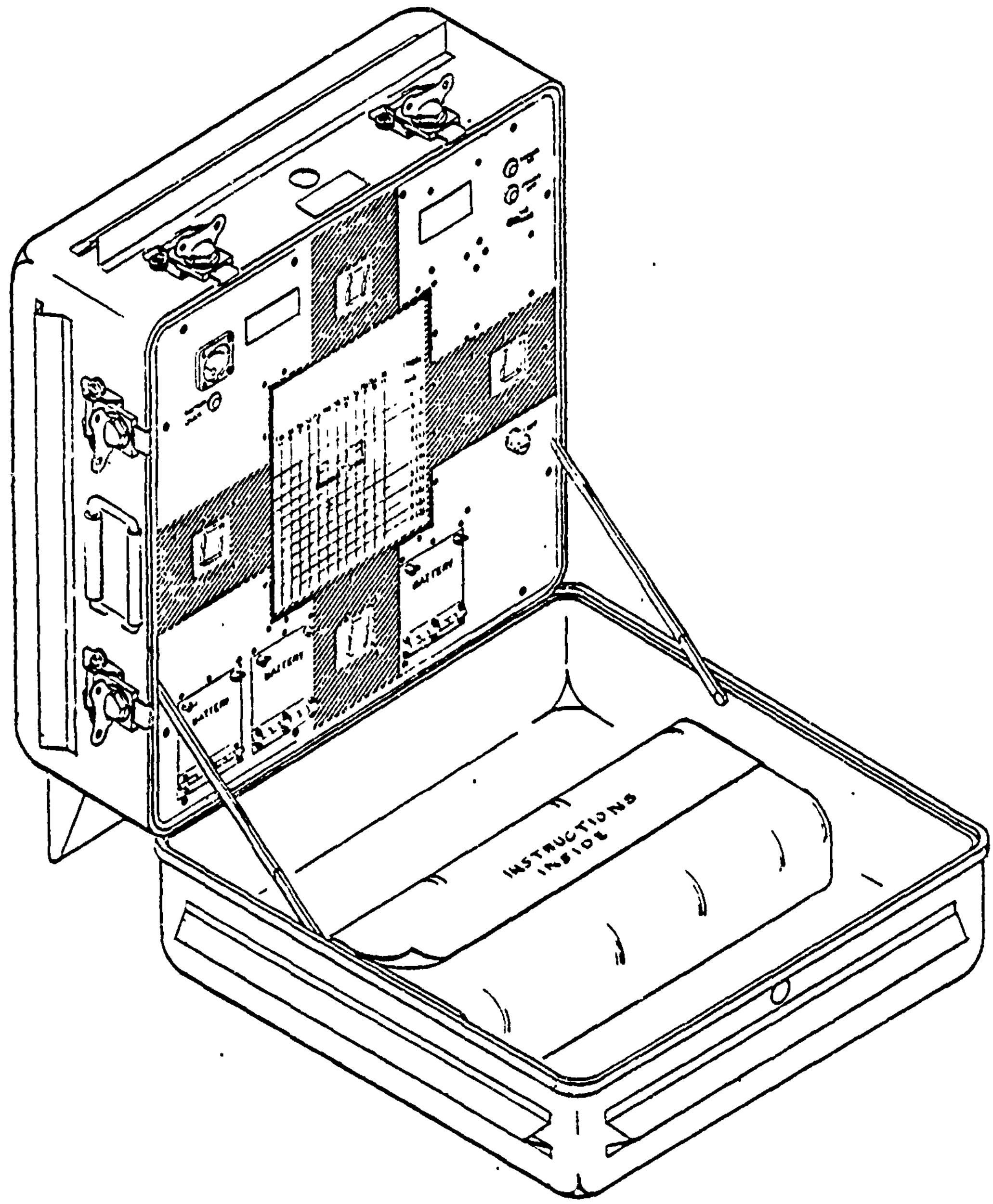

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Figure 10-5. Small Arms Alignment Fixture

Four positions on the fixture face, up, down, left, and right of center contain two digit displays. The displays are of such a size and contrast that an individual can distinguish the numerals with an unaided eye at distances up to 25 meters. The display indicates the number of sight adjustment "clicks" and direction (up, down, left, or right) that the laser beam strike point must be moved to align the laser optical axis.

10.3.2.2 Basic Operation

The alignment fixture is powered by three 6-volt lantern type batteries. The battery compartments are designed to accommodate either the MIL-Spec battery (BA200/U or BA3200/U) or the commercial equivalent batteries. Power to the fixture is turned on and off by push button switches located on the front panel. A panel-mounted voltmeter is used to measure battery voltage. The meter face is marked with a green zone to allow easy determination of the condition of the batteries. The minimum voltage as indicated by the green band on the voltmeter is 13 volts. A front panel installed push button must be pressed to connect the voltmeter into the battery circuit.

When power is first turned on, each of the four displays show the number "18." This number indicates that the displays and the electronic circuits are operating properly. The numbers remain on until receipt of the first laser round or until power is turned off. To save battery power and prevent inadvertent battery discharge, power to the fixture is automatically disconnected approximately 24 minutes after the last laser round is received. If no laser round has been received, power is disconnected 24 minutes after the fixture has been turned on. Power may be restored to the fixture by pressing the ON push button.

The number displays are electromechanical devices and require power only to change the displayed number. No power is needed to maintain the display.

The displays are triggered by receipt of the proper coded MILES laser signal on the target face of the alignment fixture. The fixture will respond only to code number 27, which is the M16A1 rifle and M60 machine gun hit code. If the transmitters are operated in the dry fire mode, the fixture will also respond to the boresight code. (The dry fire mode is normally not used on the battlefield.) The electronic circuit will reject all other codes including code number 29, which is the near miss code for the M16 and M60. Upon receipt of a valid code, the displays blank for approximately a half a second and then indicate the appropriate aim correction data.

The displays will show misalignment of the small arms sight, when the weapons are fired from a distance of 25 meters, to within ± 1 "click" of the weapon's sights. For example, a "6" in the top display and a "3" in the right side display indicates that the strike point must be moved up 6 clicks and to the right by 3 clicks in order to hit the center of the target bullseye.

A mode switch located on the front panel must be set to the type of weapon being aligned. When set for the M16 rifle, the display will read a maximum number of "11" indicating 11 clicks of sight adjustment. When set to the M60 position, the display drivers will compensate for the difference in weapon sight adjustment and will read a maximum number of "3" indicating 3 clicks of sight adjustment in the right and left displays and a maximum reading of "13" indicating 13 clicks of sight adjustment in the up and down displays.

A schematic diagram of the alignment fixture's electronic circuits is shown in figure 10-6.

10.3.2.3 Operating Principles

The circuitry of the SAAF is designed around a flat square array of 144 photodiodes approximately 6 inches on a side. This array is located behind a simulated boresight target face which is transparent to the infrared energy of the laser beam. The effective diameter of the beam is on the order of 0.5 inch at the specified 25 meter range, so that an array of this size can provide high resolution of the laser beam position.

The signals from the photodiode array are connected to a system of high-speed amplifiers and comparators, arranged so that each individual photodiode provides both a ROW and a COLUMN signal. The result is, as shown in figure 10-7, 24 parallel output lines, 12 ROW and 12 COLUMN. These are connected to microcomputer logic circuitry which monitors them, determines which laser pulse code bits are the appropriate ones, and calculates the position of the center of the laser beam by analyzing which ROW and COLUMN signal lines are active. It then compares this calculated position to the ideal position (which coincides with the center of the diode array) and sends aim correction data to large numeric displays which are located on the front panel of the SAAF, surrounding the target face.

10.3.2.4 Optical Design

The SAAF was designed around the characteristics of the M16A1 rifle. The spacing between adjacent photodiodes in the detector array is therefore 0.550 inch, which is a very close approximation of the

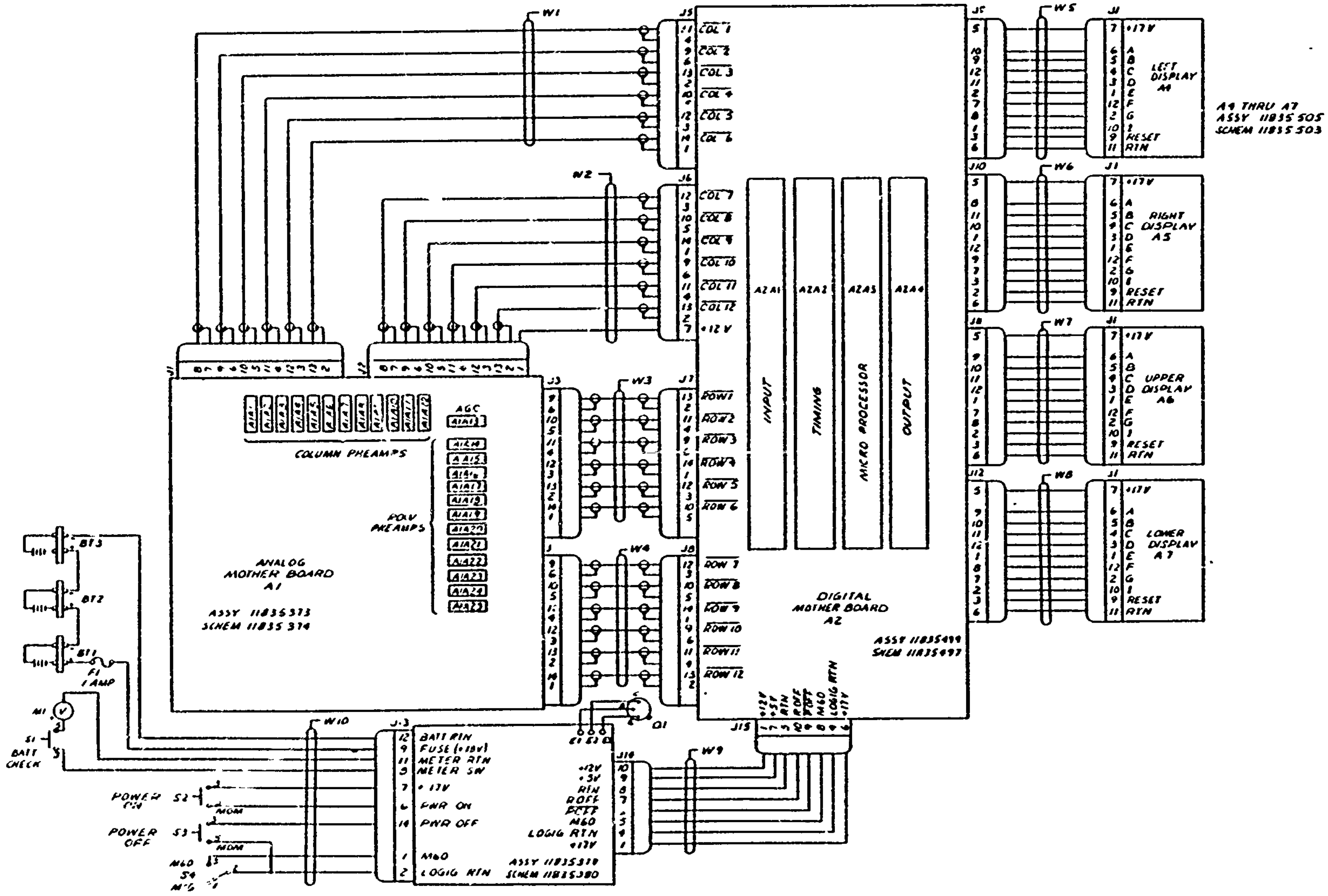

Figure 10-6. Small Arms Alignment Fixture Connection Diagram

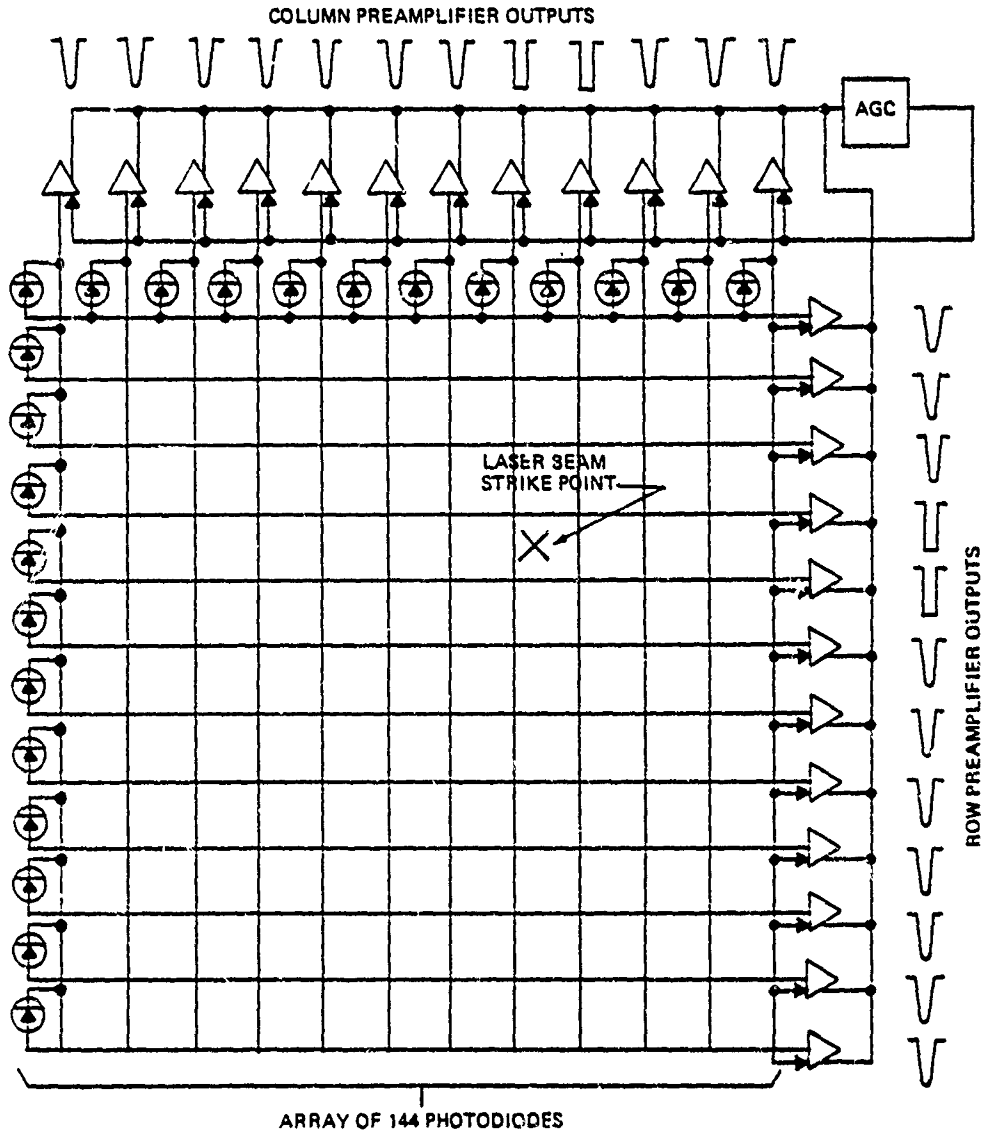

Figure 10-7. SAAF Detector Configuration

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distance the strike point moves when either the windage or elevation sights of the M16A1 are adjusted two clicks. The effective resolution of the SAAF is one click because the microcomputer is programmed to interpolate; in effect, synthesizing additional photodiodes.

Since the active area of each photodiode is only 0.10 inch in diameter, a dead area of considerable size is present between adjacent diodes; larger, in fact then the width of the laser beam, which is elliptical with the major axis aligned vertically. This potential problem is averted by including a beam-diffusing layer behind the target face. This layer spreads the beam so that several photodiodes in each axis are illuminated.

The photodiodes operate in the photoconductive mode to achieve sufficiently fast response. This means that direct sunlight would produce excessive current drain. A solar filter is therefore included in the target face sandwich, allowing 70 percent of the infrared to pass while reducing solar-induced current by a factor of four.

10.3.2.5 Analog Circuit Design

10.3.2.5.1 Photodiode Array

The photodiodes are reverse biased at approximately 12 volts and connected in a matrix configuration. Thus, the cathodes of all the photodiodes in any column are connected together and share a single load resistor and amplifier. Likewise the anodes of all the photodiodes in any row share a single load resistor and a single amplifier. In this way ROW amplifier inputs are isolated from COLUMN amplifier inputs, yet any given photodiode drives both equally and simultaneously. All load resistors are 200 ohms, which is a compromise

between low values which absorb too much of the photodiode signal, and high values which produce too much drop in the 12 volt bias voltage as a result of sunlight.

The photodiode array is housed on a large etched circuit board (the analog mother board) into which the preamplifier and AGC boards are plugged.

10.3.2.5.2 Preamplifiers

The COLUMN signals from the photodiode array are capacitively-coupled into the current-summing node of a high speed operational amplifier. Since the COLUMN signals are negative-going, the amplifier's output is positive-going and can be several volts in amplitude. The ROW signals are positive-going so that an inverter stage is needed to allow the use of an identical high-speed op-amp circuit. This inverter stage is a simple transistor circuit using a 2N918, with values selected to produce a gain of minus one.

The positive-pulse output of the high-speed amplifier is applied to an integrator circuit which serves as a pulse stretcher. The output of the integrator is fed to a comparator, along with an AGC voltage. Whenever the pulse energy from the ROW or COLUMN in question exceeds a certain level, the comparator's output goes low and this constitutes the output signal from the preamplifier board. The AGC voltage is common to all 24 preamplifiers and is supplied by the AGC board.

Each preamplifier board includes a secondary signal output which is connected to the "pulse sample" input of the AGC board.

10.3.2.5.3 AGC

The function of the AGC board is to raise the AGC voltage sent to the preamplifiers, in response to high laser beam power. Without this feature, a high-powered laser beam could activate too many ROW and COLUMN signals for the logic circuits to correctly interpret. The task of the AGC circuit is to control the AGC voltage so that approximately six signal lines are active during the critical period when the logic circuits store ROW and COLUMN data. This occurs during the third HIT word, so that the AGC circuit must finish its task by the end of the second HIT word.

The "pulse sample" input to the AGC circuit is configured so that seven or more ROW and COLUMN outputs are required to have an effect on the AGC voltage, which has a quiescent value of about 0.1 volt. The magnitude of the effect is roughly proportional to the difference between the number of active outputs and six.

When a high-powered laser beam is received, the first bit of the first word will activate many ROW and COLUMN outputs. This will, in turn, cause a stepwise increase in the AGC voltage, which has a long relaxation time constant. The second bit will cause a similar increase, but somewhat smaller since fewer outputs are now active. This procedure continues until about six outputs are active. At that point the AGC voltage stops increasing, and decreases so slowly that it is essentially constant for the remainder of the four HIT words.

10.3.2.5.4 Regulator

The regulator board has two basic functions. The first is to provide constant voltage levels to the analog (12 volt) and digital (5 volt) circuitry so that performance does not vary as battery voltage decreases from 18 volts to 13 volts.

The second function is to accommodate the automatic turn-off feature of the SAAF. This feature is very desirable since it extends battery life considerably; however, it means that the power-on and power-off switching of the SAAF cannot be performed with the usual toggle switch. Instead, the regulator is designed to latch in the power-on mode in response to the actuation of a momentary pushbutton switch, and to be reset either manually by a second pushbutton switch or automatically by a logic signal approximately 24 minutes after the last display update.

Battery life is also extended by the use of a discrete transistor pass element instead of an integrated-circuit regulator. This allows the batteries another 1.5 to 2 volts of decrease before they must be replaced.

10.3.2.6 Digital Circuit Design

10.3.2.6.1 Timing and Decoding

The logic circuitry interfaces with the analog circuitry (preamp and AGC circuits) only during the first three words of the received laser message. The associated waveforms are shown in figure 10-8.

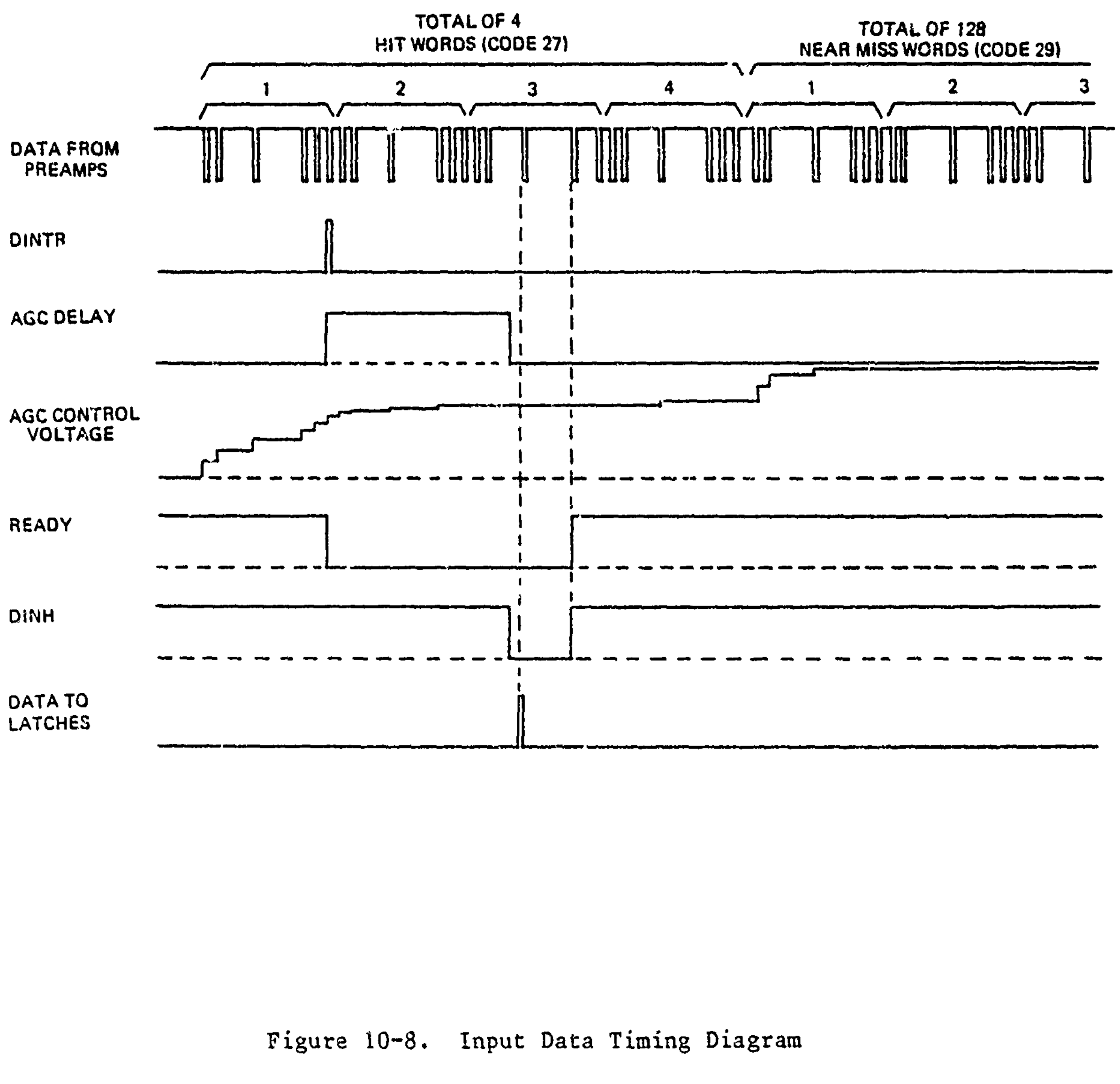

Figure 10-8. Input Data Timing Diagram

A composite of all ROW preamp data is sampled by several logic circuits. The presence of the small arms HIT code (code 27) is detected at the end of the first HIT word and a DATA INTERRUPT (DINTR) pulse is produced. This pulse triggers a monostable multivibrator (one-shot) with a period of 3.9 milliseconds. Its purpose is to delay data sampling until the third HIT word, at which time the analog AGC control voltage will have settled to an acceptably steady level. This is important in getting a good data sample, particularly if the laser transmitter being used is of greater than average output power. The DINTR pulse also signals the microprocessor to blank all displays.

At the end of the AGC DELAY period, a window is created by the action of the DATA INHIBIT (DINH) signal, and the first data pulse to occur during this window is the one which is received by the data latches. There is a data latch for each ROW and each COLUMN data line; of these 24, the AGC action previously described ensures that no more than about six receive data. The second data pulse to occur after the opening of this window causes the window to close and signals the microprocessor to begin data analysis.

The microprocessor first sequentially examines the contents of the COLUMN data latches, beginning with the left column (as seen from the firing position). It notes the column numbers of the first and last latches to contain data, and from this calculates the position of the center of the laser beam in the horizontal axis. The program allows this calculation for both odd and even quantities of active data latches; therefore the microprocessor is capable of providing a position resolution (one M16 sight click) twice as fine as the spacing of the detectors (two M16 sight clicks). When the microprocessor has found this position data, it stores the appropriate ROM look-up address in its internal memory, and then repeats the entire process with the ROW data to find the center of the beam in the vertical axis.

When these operations are completed, the microprocessor causes the display registers on the output board to receive display information from the two ROM look-up addresses which resulted from the calculations described above.

Approximately one-half second after the displays were blanked, a strobe pulse is initiated which sends the new display information to the display boards. The half-second of blanked displays serves to notify the firer that his laser "round" has been received.

10.3.2.6.2 Weapon Modes

The SAAF will operate with the MILES system of either the M16A1 rifle or the M60 machine gun, since both use the same HIT and NEAR MISS codes and format. The sight adjustment increments of the two weapons differ, however, so that a switch is incorporated on the SAAF front panel to let the logic circuits know what number to display. Accordingly, the ROM contains separate look-up tables for the M60 with numbers appropriate for the M60 sight adjustment characteristics.

10.3.2.6.3 Displays

Each of the four numeric displays of the SAAF consists of an etched circuit board on which are mounted two seven-segment electromagnetic dislays, two integrated circuit drivers, and a large filter capacitor. A portion of the tens digit display is masked, since the highest number to be displayed is 18.

Operation of the SAAF from batteries limits the choice of display types to either liquid crystal or electromagnetic. Liquid crystal displays capable of operating over the required temperature range do not exist. The electromagnetic devices are acceptable because they draw power only when changing numbers.

The driver circuits receive signals directly from the digital circuits located on the output logic boards. No data manipulation takes place on the display boards.

The value of the filter capacitor is several thousand microfarads and stores sufficient energy to allow all nine active display segments to be driven simultaneously without allowing the voltage to drop below 9 volts.

The display boards are powered directly from unregulated voltage with only the polarity-protection diode of the regulator board between them and the battery potential. However, to restrict the high display-drive currents to the display boards, each filter capacitor is isolated by a 68 ohm resistor.

10.4 QUALITY ASSURANCE TESTING

The XEOS Quality Assurance program has been organized to ensure quality throughout all areas of fabrication, processing, assembly, inspection tests, maintenance, preparation for delivery, and shipping. Certain requirements, such as testing, may be considered common to both the Quality and Reliability programs.

Two types of inspections are performed: (1) First Article Inspection; and (2) Quality Conformance Inspection.

10.4.1 FIRST ARTICLE INSPECTION

Both the Vehicle Test Set and the Small Arms Alignment Fixture will be subject to various operating and non-operating environmental tests in accordance with the requirements of MIL-STD-810, Environmental Test Methods. The tests to be conducted are documented in CDRL item AOOY of the contract and include the following:

Vehicle Test Set:

a. Operating
   - High Temperature
   - Low Temperature
   - Low Pressure
   - Humidity
   - Rain

b. Non-operating

- Shock
- Vibration
- Dust
- Salt Fog
- Loose Cargo

Small Arms Alignment Fixture

a. Operating

- High Temperature
- Low Temperature
- Low Pressure
- Humidity
- Rain

b. Non-operating

- Shock
- Vibration
- Dust
- Salt Fog
- Loose Cargo

Operational testing of both the Vehicle Test Set and Small Arms Alignment Fixture is accomplished by observing the response on the meters and indicators to simulated signal inputs. The Test Set and SAAF have both successfully completed their respective environmental tests.

10.4.2 RELIABILITY AND MAINTAINABILITY

The test set and alignment fixture have both been designed to meet the reliability requirements of MIL-STD-781, Fixed Ground Test Conditions, Thermal Stress B, PRST-Test Plan VIII C.

The quantative reliability in terms of Mean-time-between failure (MTBF) for the Vehicle Test Set and Small Arms Alignment Fixture are as follows:

Vehicle Test Set

Specified Value (θ_o) = 800 hours
Minimum acceptable value (θ_1) = 400 hours

These vehicle test sets were subjected to Reliability testing and underwent 147 hours each or a total of 441 hours without failure, thereby exceeding the minimum MTBF of 400 hours.

Small Arms Alignment Fixture

Specified Value (θ_o) = 400 hours
Minimum acceptable value (θ_1) = 200 hours

The general reliability requirements are to subject the sample test sets to an elevated temperature of $40 \pm 5^\circ C$ and 2.0 ± 0.2 g vibration at a non-resonant frequency between 20 and 60 Hz. The Vehicle Test Set will then be tested for proper readings of bit rate, voltage, and proper CVKI simulation.

The Small Arms Alignment Fixture will be tested to assure the unit responds to the code number 27 (which is the hit code for the M16A1 rifle and the M60 machine gun) and not respond to code number 29 (which is the near miss code for these weapons).

Two SAAF test sets were subjected to reliability testing and underwent 110 hours each for a total of 220 hours without failure, thereby exceeding the minimum MTBF of 200 hours.

Maintainability in terms of Mean-Time-To-Repair (MTTR) will be as follows:

Vehicle Test Set

Required Value (M_o)	= 60 minutes
Desired Value (M_1)	= 30 minutes
Actual (from Maintainability Demonstration)	= 19 minutes

Small Arms Alignment Fixture

Required Value (M_o)	= 120 minutes
Desired Value (M_1)	= 60 minutes
Actual (from Maintainability Demonstration)	= 28 minutes

APPENDIX A

POWER REQUIREMENTS

APPENDIX A

POWER REQUIREMENTS

A.1 TEMPERATURE EFFECTS ON BATTERIES

MILES Specification N2234-122, subsection 3.4, defines the environmental criteria for the MILES training device. The referenced specification requires a performance from -25°F to +110°F. The detailed requirements include operation at temperatures greater than 105°F for four hours out of each 24 hours, with operation at 110°F for a maximum of one hour out of 24 hours. Low temperature requirements include operation at -25°F for a maximum period of six hours out of 24 hours. Analysis of the characteristics of various types of dry batteries available for this application has been performed and two types of battery chemical systems have been chosen to operate MILES. See table A-1 and figure A-1 for data.

It has been concluded that alkaline batteries (alkaline-manganese-zinc) will be used for temperatures down to 26°F. Temperatures below 26°F will require the use of a new lithium organic battery. Figure D-2 gives the curves relating the two batteries.

The use of these two types of dry batteries for electrical power will satisfy the temperature requirements of the MILES program.

A.2 TOTAL CURRENT DRAIN

Portable weapons and detector systems have been designed to have very low current drain so that the common 9-volt "transistor" type of battery is used in these devices (see table A-1).

TABLE A-1

BATTERY, 100 HOURS, $70^{o}F$ LOAD CURRENT

Battery Type	Availability Status	Max/Min Voltage (V)	$70^{o}F$, 100 hours Load Current Capability (mA)	Lowest Qual. Test Temp. (^{o}F)	MILES Application
Alkaline					
Mallory P/N MN1604 (MIL-B-18D) P/N BA3090/U)	Commercially mass produced. Being qualified for Military	9.0/6.0	5	-0-	Portable Systems down to $26^{o}F$
Lithium Organic					
Mallory (MIL-B-18D, P/N BA5090/U)	Developed and being packaged for Military Qualification		6.5	-20	Portable Systems below $26^{o}F$
Carbon Zinc (MIL-B-18D P/N BA-200/U)	Available in Federal supply system	6.0/4.5	37.5	-70	Vehicle Systems down to $26^{o}F$
Alkaline					
BA-3200/U (MIL-B-49030)	Available in Federal supply system	6.0/4.5	118	-0-	Vehicle Systems below $26^{o}F$

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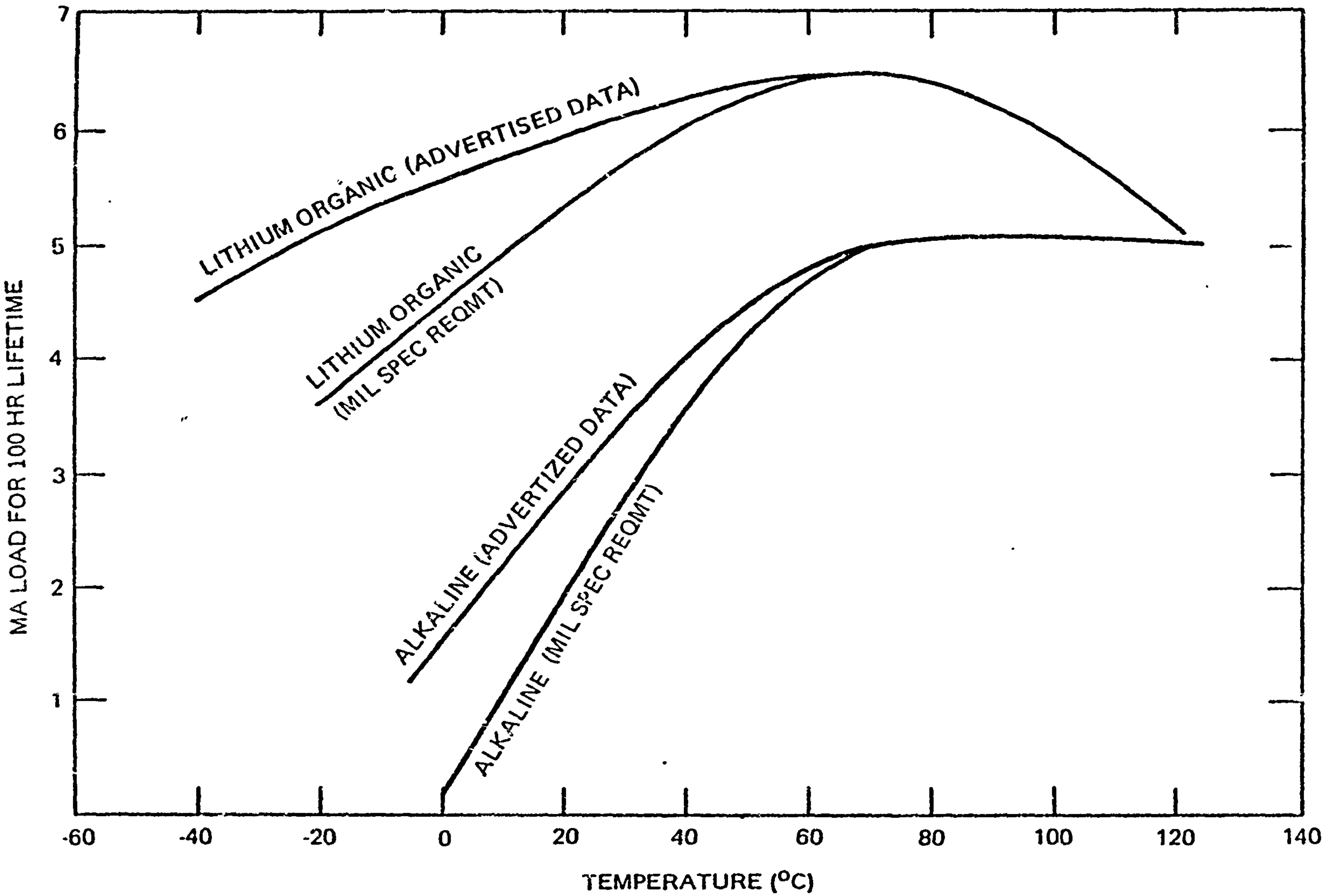

Figure A-1. Comparison of Lithium Organic and Alkaline Battery Load Capabilities for 100 hr/6 volt End of Life Definition

The vehicular systems require more power than the portable systems. As a consequence, a 12-volt source made up of 2 6-volt lantern batteries is used as a power source so that satisfactory continuous operating time may be obtained.

Table A-2 shows typical current drain for each simulator. It will be noted that the requirements match the battery capabilities quite well so that more than 100 operating hours per battery can be obtained in most cases.

A.3 VEHICLE POWER

The MILES vehicle system interfaces with vehicle power in two cases: (1) as a power source for the kill indicator and, (2) for trigger signals.

The kill indicator, a strobe light, is switched to vehicle power by relays at the kill indicator. There is no conductive connection between vehicle power and the MILES electronics.

TABLE A-2

BATTERY CURRENT DRAIN

	Typical Current Drain (per Battery)-mA
A. MWLD	
Harness	2.5
Helmet	1.5
B.	
Laser Transmitter - M16A1	2.5
Laser Transmitter - M60 Machine Gun	2.5
Laser Transmitter - M2 Machine Gun	2.5
Laser Transmitter - M85 Machine Gun	2.5
Laser Transmitter - DRAGON	3.0
Laser Transmitter - VIPER	3.0
C. M60A1/A3	
Laser Transmitter - 105 mm	
Laser Transmitter - Coax Machine Gun	
CVLD	* 25.0
CVKI	
LCA	
D. M60A2/M551	
Laser Transmitter - 152 mm	
Laser Transmitter - Coax Machine Gun	
CVLD	* 25.0
CVKI	
LCA	
E. APC - M2 Machine Gun	
Laser Transmitter - M2 Machine Gun	2.5
CVLD	
CVKI	* 20.0
CIA	
F. TOW	
Laser Transmitter - TOW	2.5
Receiver	* 2.5

*Uses two 6V lantern batteries in series

APPENDIX B

TEMPERATURE ENVIRONMENT ANALYSIS

APPENDIX B

TEMPERATURE ENVIRONMENT ANALYSIS

B.1 TEMPERATURE

The environmental extremes to which the laser transmitter will be exposed are defined in AR70-38; "Research, Development, Test, and Evaluation of Material for Extreme Climate Conditions," 1 July 1969. Applicable environments are summarized below:

	Operational Conditions			Storage & Transient Conditions	
Climatic	Ambient Air Temp °F	Solar Radiation BTU/hr-ft	Ambient Rel. Hum. %	Air Temp °F	Induced Rel. Hum. %
5 Intermediate Hot-Dry	70 to 110	0 to 360	20 to 85	70 to 145	5 to 50
6 Intermediate Cold	-5 to -25	-	Tending Toward Saturation	-10 to -30	Tending Toward Saturation

The transmitter temperature limits, prior to firing blanks, are calculated from the following energy balance:

$$\alpha G A_R = \epsilon A(\sigma T^4 - \sigma Ta^4) + hA\ (T - Ta) \qquad (1)$$

where

A_R = Area of simulator receiving solar radiation (ft^2)

A = Total area of simulator (ft^2)

G = Solar radiation (BTU/hr ft^2)

T = Simulator temperature (°F)

Ta = Ambient temperature (°F)

h = Convective heat transfer coefficient (BTU/hr ft^2 °F)

α = Solar absorptivity

ϵ = Emissivity

σ = Stephan-Boltzmann Constant (BTU/hr ft^2 °R^4)

Solution of equation (1) yields an equilibrium simulator temperature of 145°F for category 5 and -25°F for category 6.

Firing blank ammunition heats the barrel of the weapon. This heated barrel, in turn, conducts heat through the simulator adapter into the weapon simulator, causing the simulator temperature to rise. Barrel temperature data were obtained experimentally for both the M-16 and the M-60 to provide simulator adaptor design criteria.

The results of the testing are summarized in figures B-1 and B-2. Data from the first figure shows the M16 barrel temperature rising from 73°F to 560°F in five minutes while expending 190 rounds of blank ammunition. The M60 machine gun barrel temperature (figure B-2) is shown to increase from 73°F to 905°F while expending 750 rounds of blank ammunition. In each case the highest temperature reached would be about 70°F higher than measured if the initial temperature had been 145°F, as calculated for environmental category 5 of AR 70-38.

A computer model of the simulator/adapter has been developed to support hardware design. This preliminary model has been updated to reflect a current design configuration. The computer model is shown in figure B-3. This model is three dimensional and has the capability of calculating transient temperature response for either constant or time varying heat inputs and/or boundary conditions.

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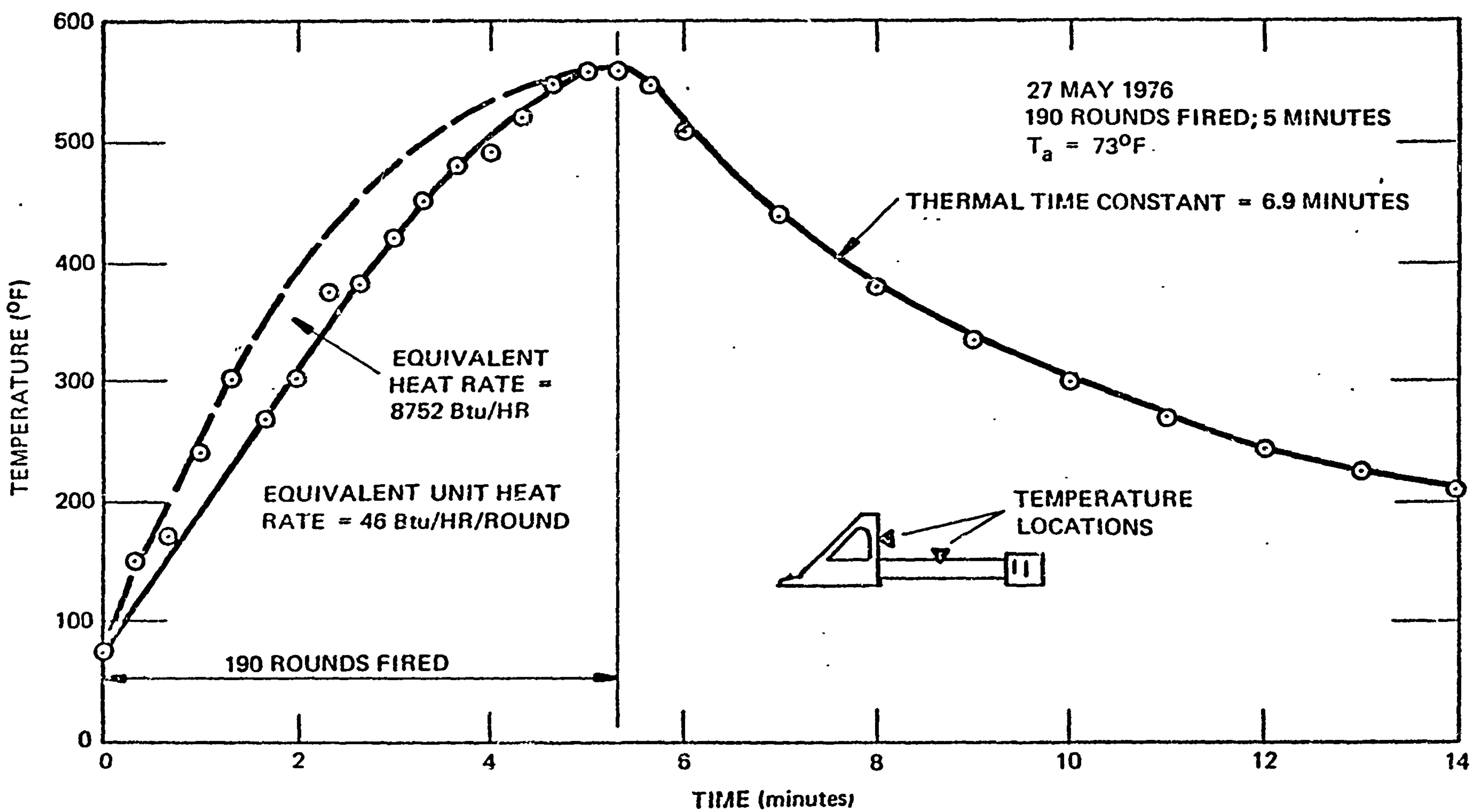

Figure B-1. Temperature History M16A1 Rifle

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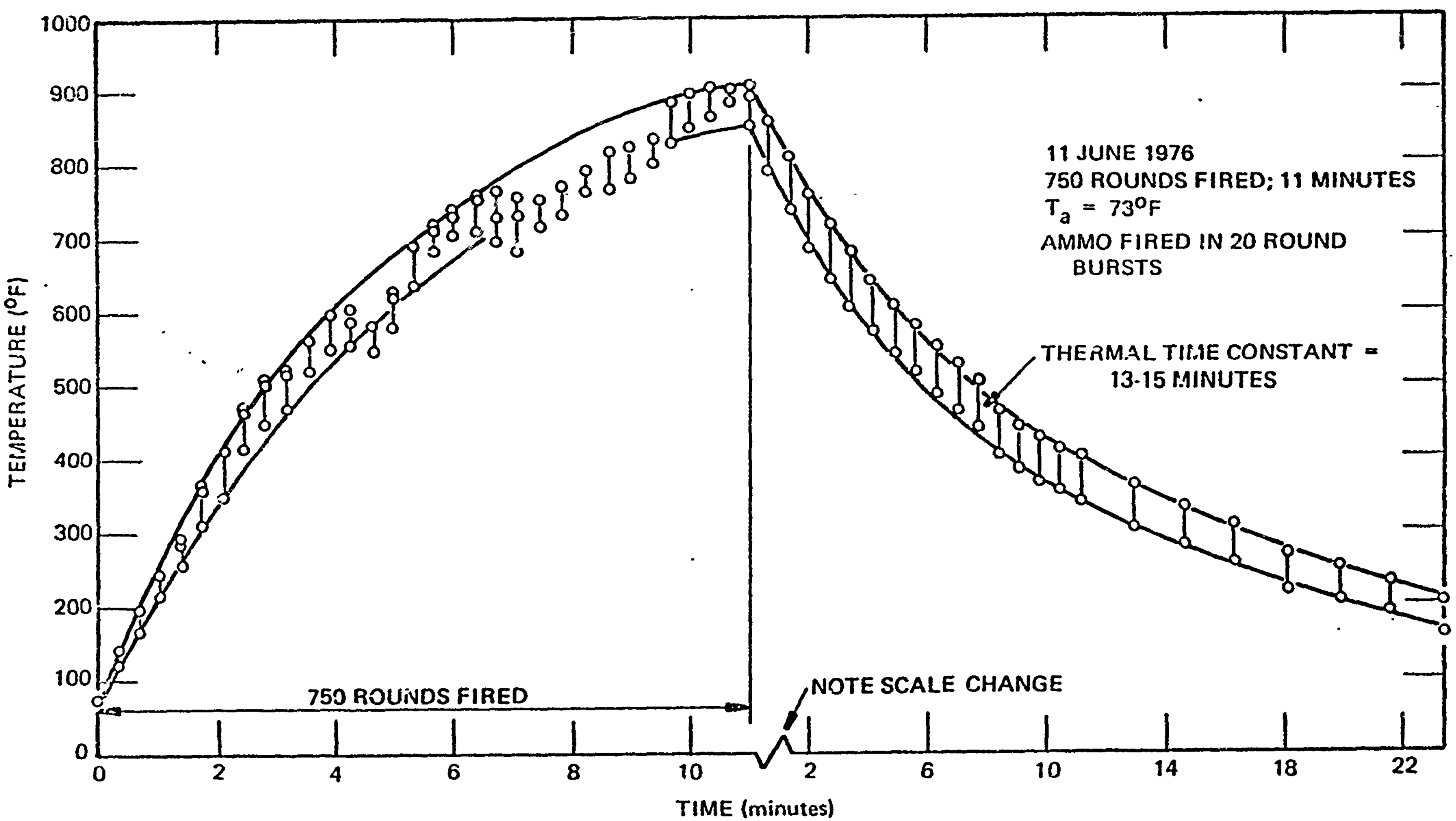

Figure B-2. Temperature History M60 Machine Gun

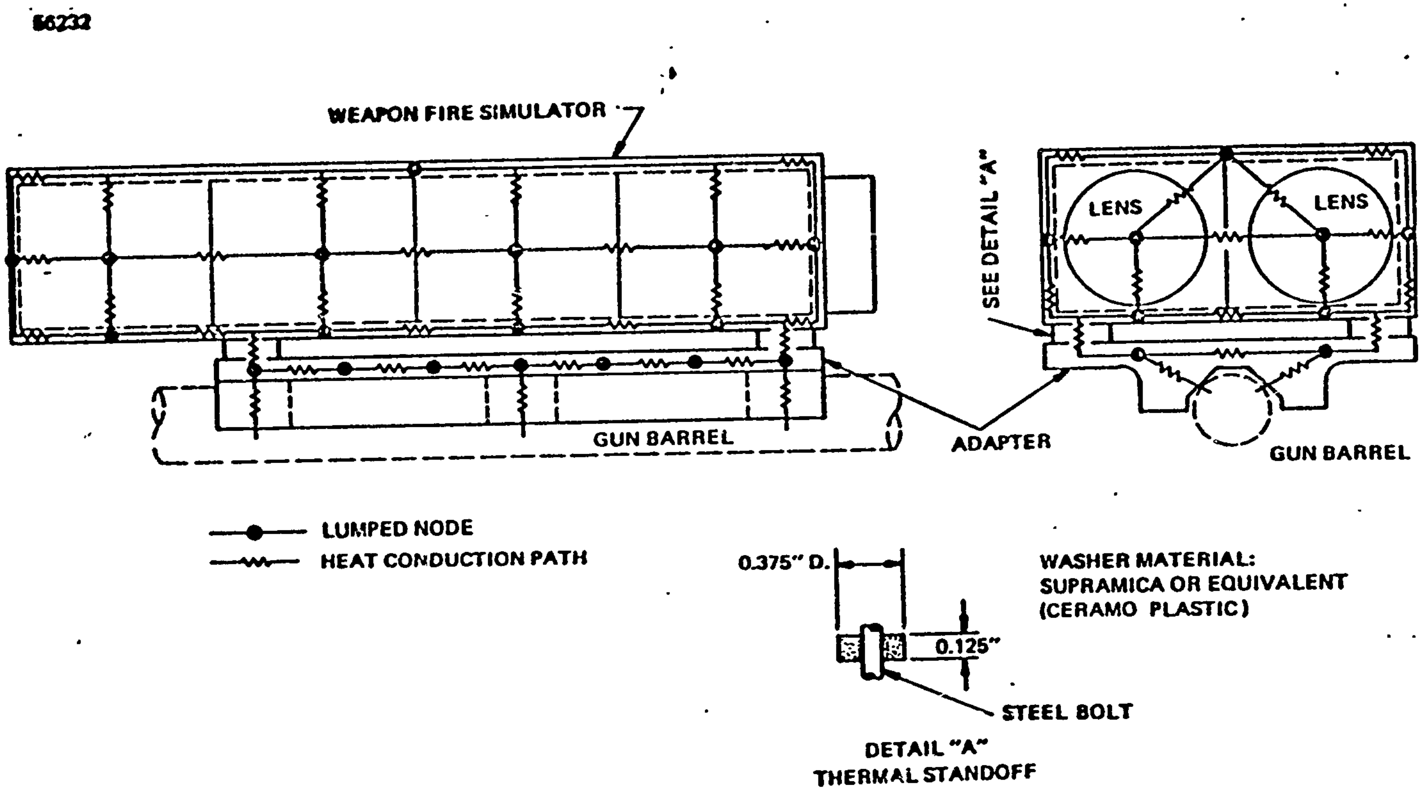

Figure B-3. Weapon Fire Simulator/Adaptor Computer Model

Calculated simulator temperatures for a hypothetical firing sequence (see figure B-4) show an increase of 45°F in a period of 16 minutes with an expenditure of 100 rounds of blank ammunition.

The computer model will continue to be refined as the design evolves and will be used to analytically verify the thermal design of the final configuration. Values of the thermal insulation material used in the model are listed in table B-1.

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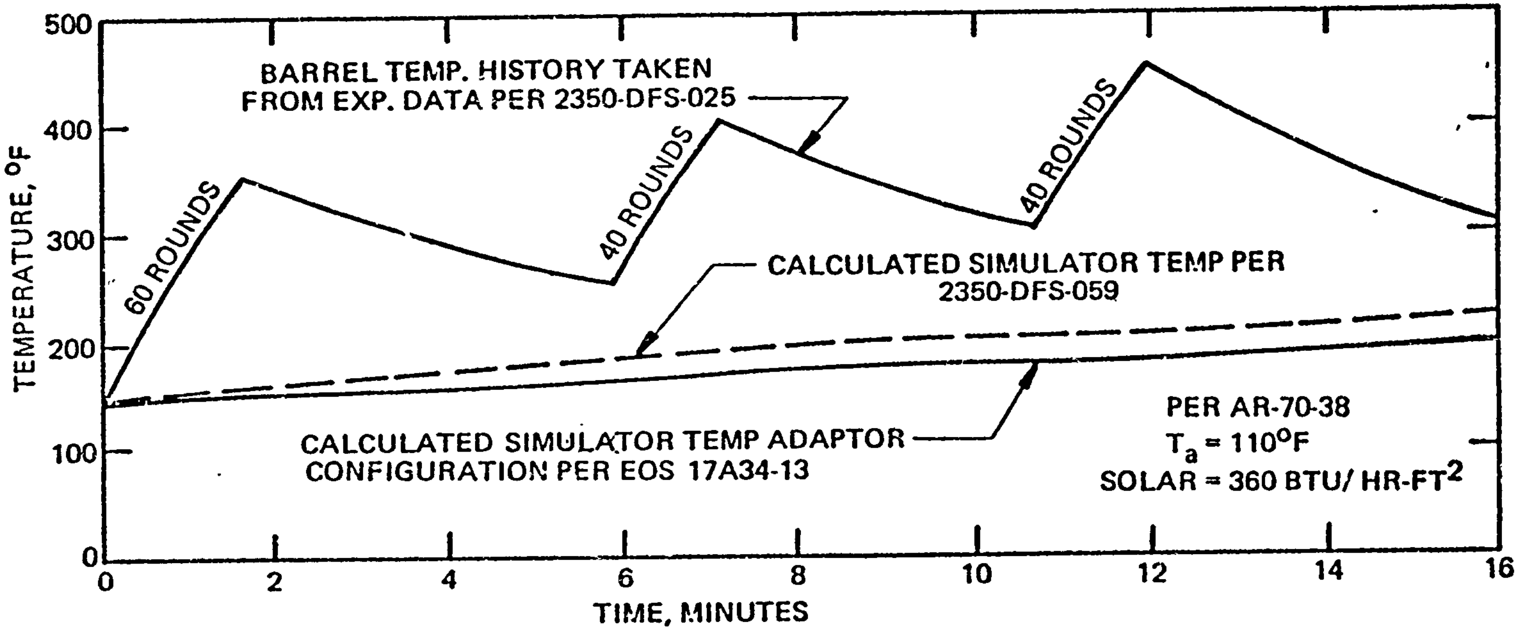

Figure B-4. Weapon Fire Simulator Temperature History

TABLE B-1

PHYSICAL - ELECTRICAL - THERMAL PROPERTIES

	Supramica 620 "BB" Ceramoplastic Precision-Molded
Dissipation Factor 10^6 cycles/sec	0.0023
Dielectric Constant 10^6 cycles/sec	8.8
Loss Factor 10^6 cycles/sec	0.020
Dielectric Strength 1/8" thick v/mil	270
Arc Resistance ASTM Seconds	300
Maximum Temperature Endurance ^oF	1200
Thermal Expansion $10^{-6}/^oC$	9.4
Thermal Conductivity cal/cm^2 sec ^oC/cm	0.0012
Tensile Strength psi	5,000
Compressive Strength psi	30,000
Flexural Strength psi	12,000
Modulus of Elasticity 10^6 psi	12.0
Impact Strength Charpy ft. lbs. per sq. in.	1.2
Water Absorption 1/8" thick 24 hours - %	nil
Specific Gravity	3.8

APPENDIX C
SPECTRAL FILTER ANALYSIS

APPENDIX C

SPECTRAL FILTER ANALYSIS

C.1 INTRODUCTION

The dominant source of noise in the MILES detector/amplifier circuit is shot noise resulting from the solar background. Thus, one important aspect of noise reduction in MILES is the spectral filter. From the Shottky equation, the shot noise is given by

$$I_n = \sqrt{2eBI_b}$$

where

I_n = shot noise current
I_b = background current
e = unit electrical charge
B = system electrical bandpass

The prime functions of the spectral filter are therefore:

a. To reduce I_b to the smallest possible value while
b. Maintaining the maximum possible signal transmission at GaAs wavelength.

C.2 ANALYSIS

Sunlight is the dominant MILES background source. Figure C-1 shows the solar spectral distribution at earth sea level (i.e., including atmospheric absorption) as taken from References 10-12. The function $S\lambda$ has been normalized to 100 percent at the maximum spectral irradiance level at 5000Å.

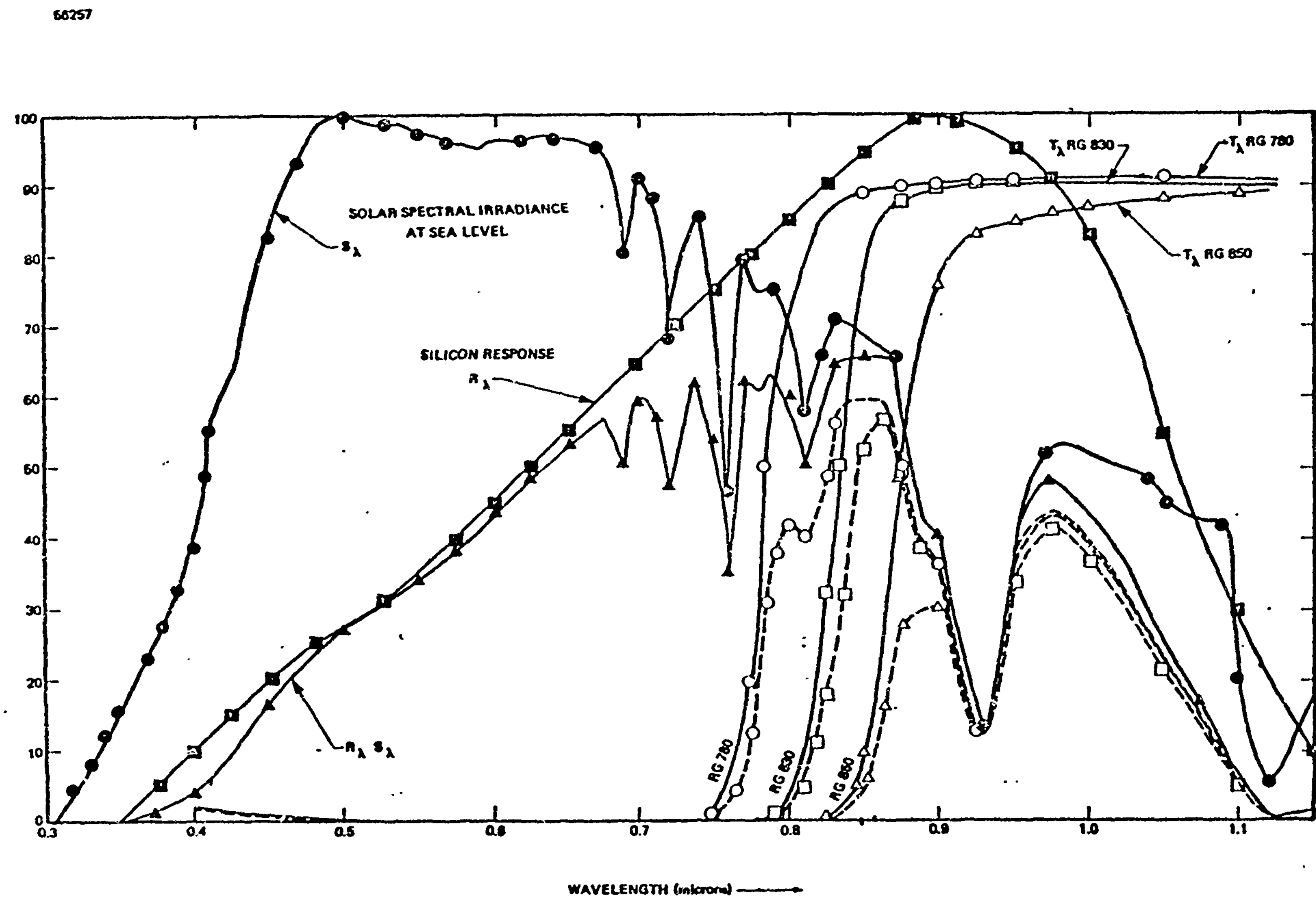

Figure C-1. Solar Spectral Distribution with Silicon Detector and Filter Plots

Furthermore, since MILES will utilize silicon detectors, the silicon detector spectral responsivity, R_λ, is shown as the dashed curve on figure C-1. The product function, $R_\lambda S_\lambda$, represents the fundamental spectral response of a silicon detector to sunlight. This is shown by the solid curve.

Next, the transmission, T_λ, of an RG 780, RG 830, and RG 850 filter is plotted with respect to wavelength. Figures C-2, C-3, and C-4 show experimentally measured filter transmission with respect to wavelength plots which were obtained using a Beckman DK-2 Spectrophotometer. The data were obtained at two arbitrary locations on each Shott filter to check for repeatability. Each plot is, therefore, actually an overlay of two different plots corresponding to two arbitrary locations. The repeatability is excellent for all three filters with the only variations occurring at $\lambda > 0.9\mu$ for the RG 850 filter. In the region $0.4 \leq \lambda \leq 0.8\mu$, the plots were repeated a third time, but with the scale expanded by a factor of ten to check transmission in the visible. Except for about 2 percent transmission at $\lambda = 0.4\mu$ (where the silicon detector response is low), the average transmission is less than 0.1 percent from 0.5 to 0.7μ for all three filters. The three filter curves have similar shapes but are displaced from one another in wavelength. Multiplying the transmission curve for the RG 780 by $R_\lambda S_\lambda$, the spectral response of a silicon detector to sunlight is obtained as seen through an RG 780 filter. Similar curves are then generated for $T_\lambda R_\lambda S_\lambda$ for the RG 830 and RG 850 filters, respectively. These are the three dotted curves under the $R_\lambda S_\lambda$ curve. Since the overall response of a silicon detector to sunlight is given by

$$R_{sun} = \int_0^\infty R_\lambda S_\lambda \, d\lambda$$

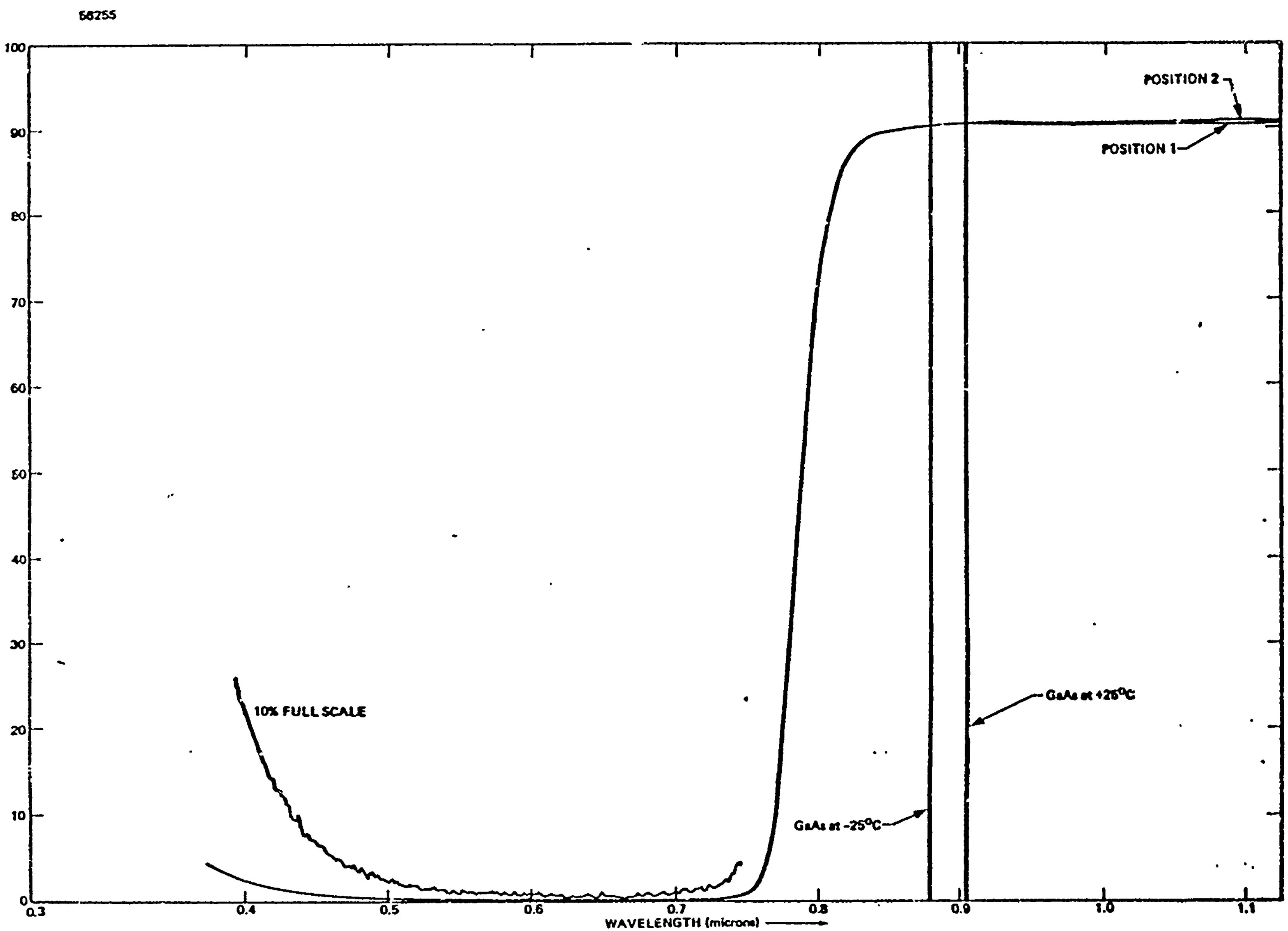

Figure C-2. Spectral Response RG 780 Filter

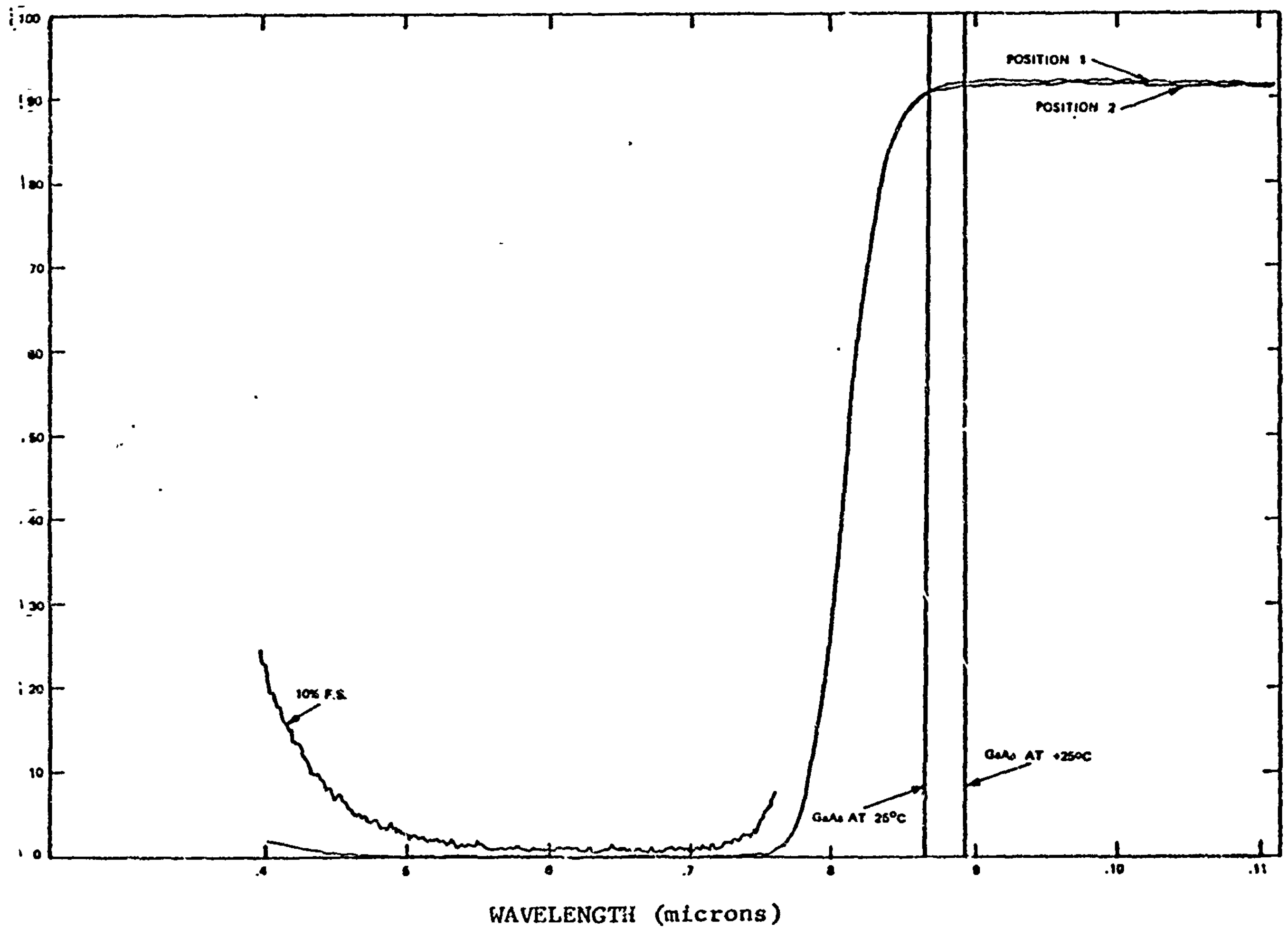

Figure C-3. Spectral Response RG 830 Filter

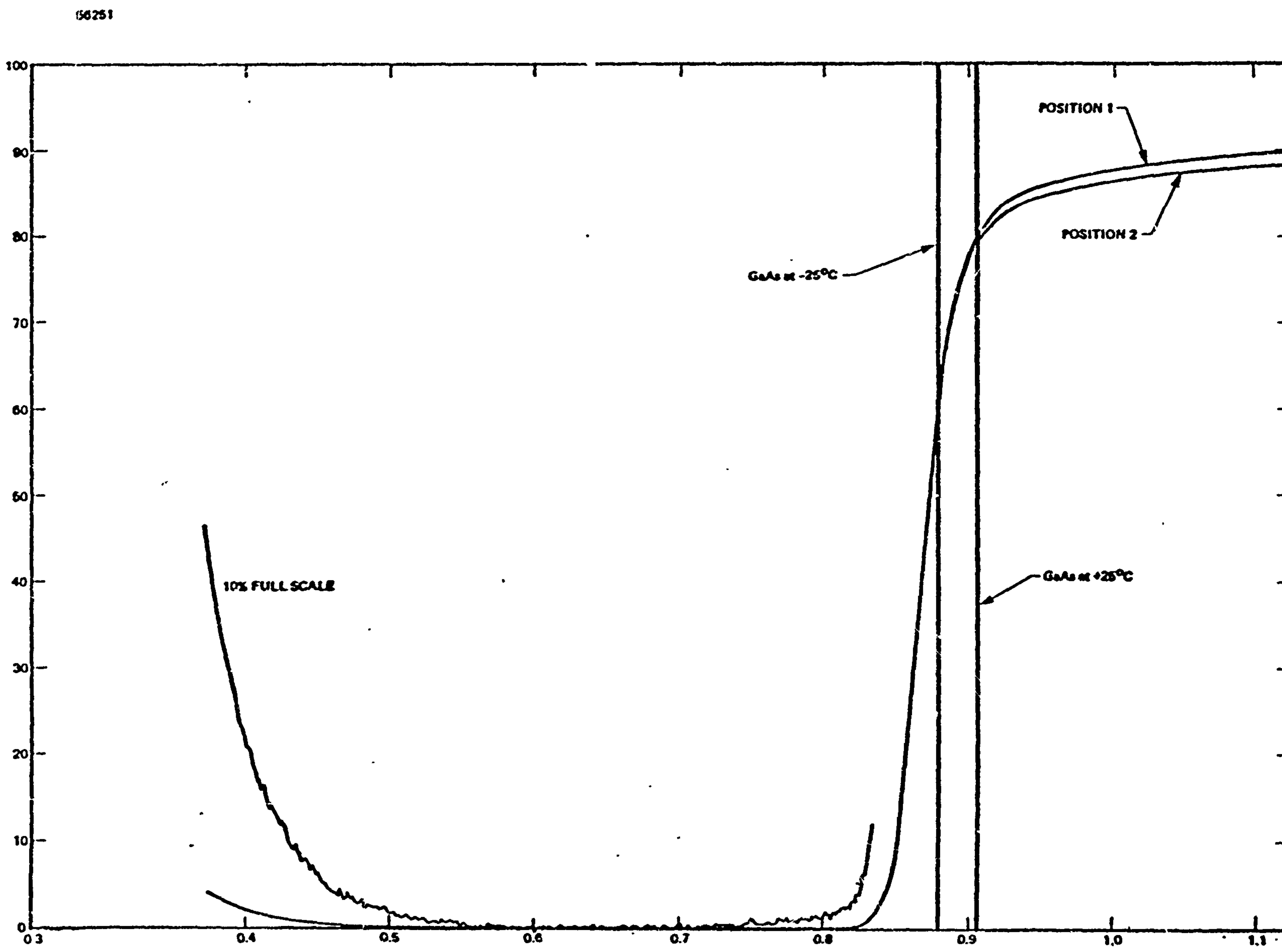

Figure C-4. Spectral Response, RG 850 Filter

then the response for a given filter is

$$R_{filter} = \int_0^\infty T_\lambda R_\lambda S_\lambda \, d\lambda$$

If we then normalize the filter performance relative to the direct sunlight case (i.e., no filter at all), we obtain

$$N_{filter} = \frac{\int_0^\infty T_\lambda R_\lambda S_\lambda \, d\lambda}{\int_0^\infty R_\lambda S_\lambda \, d\lambda}$$

Direct numerical integration of these analytically developed curves yields

$$N_{RG\ 780} = 0.391$$

$$N_{RG\ 830} = 0.307$$

$$N_{RG\ 850} = 0.264$$

Thus, the dc background currents using the RG 780, RG 830, and RG 850 filters, respectively, should be 39.1 percent, 30.7 percent, and 26.4 percent of the levels with no filters. Since the transmission at $\lambda = 9040\text{Å}$ (i.e., GaAs at $+25^\circ C$), with allowance for reflection losses, is 90.6 percent, 89.6 percent, and 78.5 percent, respectively, (values from C-1 including reflection loss) then we may define a quality index as follows:

$$Q \equiv \frac{T_{9040\text{Å}}}{\sqrt{N}}$$

where $T_{9040\text{Å}}$ is the filter transmission at 9040Å. In effect, Q is directly proportional to signal-to-noise ratio since an increase in transmission at λ = 9040Å will increase the signal, while an increase in N will increase the shot noise in a square-root fashion. Thus, upon substitution we find:

No Filter: $$Q_{\text{No Filter}} = \frac{1.000}{\sqrt{1.000}} = 1.000$$

RG 780: $$Q_{780} = \frac{0.906}{\sqrt{0.391}} = 1.449$$

RG 830: $$Q_{830} = \frac{0.896}{\sqrt{0.307}} = 1.617$$

RG 850: $$Q_{850} = \frac{0.785}{\sqrt{0.264}} = 1.528$$

thus it can be seen that the use of an RG 780 filter should increase S/N by about 45 percent relative to no filter at all. Further, the use of an RG 830 increases S/N by about 62 percent, but there is a small decrease to only 53 percent in going to the RG 850. Also, the RG 780 and RG 830 are identical in price while the RG 850 is about 50 percent more expensive than either the RG 780 or RG 830. Finally, the temperature coefficient of GaAs is about 3Å/°C. At -25°C, relative to +25°C, the wavelength shift will be -150Å. Since the GaAs laser center wavelength is 9040 ±100Å, then in a worst-case condition the laser output could occur at

$$\begin{aligned}\lambda &= 9040 - 100) - 150 \\ &= 8790\text{Å}\end{aligned}$$

The transmission of the RG 830 at $\lambda = 8790\text{Å}$ is still 89 percent, including allowance for two surface reflection losses, while the comparable value for the RG 850 is only 6 percent. Hence at low temperature we find

$$\left.\begin{aligned} Q_{\text{No Filter}} &= 1.000 \\ Q_{\text{RG 780}} &= 1.440 \\ Q_{\text{RG 830}} &= 1.606 \\ Q_{\text{RG 850}} &= 1.187 \end{aligned}\right\} \text{ at } -25^{\circ}\text{C}$$

Thus, the low temperature performance of the RG-830 significantly exceeds that of the RG 850.

C.3 EXPERIMENTAL RESULTS

A silicon cell supplied by sensor technology (a so-called "ultracell") was connected across a 1.0 ohm load resistance and the voltage drop read with a digital voltmeter. The silicon cell was positioned in direct sunlight on the roof of XEOS Building No. 101 on 28 June 1976, and a dc background of 21.0 mV was recorded with no filter present. The dc background was recorded on a Hewlett-Packard Model 3469-B digital voltmeter. The results were as follows:

Filter	dc Background (mV)	Normalized
No Filter	21.0	1.000
RG 780	7.8	0.375
RG 830	6.1	0.293
RG 850	5.2	0.248

Using the manufacturer's transmission data at 9040Å for the three filters,* the experimental data result in the following quality factors:

No Filter: $$Q = \frac{1.000}{\sqrt{1.00}} = 1.000$$

RG 780: $$Q = \frac{0.906}{\sqrt{0.375}} = 1.479$$

RG 830: $$Q = \frac{0.896}{\sqrt{0.293}} = 1.655$$

RG 850 $$Q = \frac{0.785}{\sqrt{0.248}} = 1.576$$

C.4 CONCLUSIONS

a. Analysis of solar spectral irradiance data, silicon detector response data and spectral transmittance data for RG 780, RG 830, and RG 850 filters shows significant improvement in signal-to-noise ratio is possible with all three filters.

b. At room temperature, the performance of the RG 830 and RG 850 filters for the detection of GaAs radiation by a silicon detector against a solar background in a shot noise dominated condition is almost the same, with a slight edge to the RG 830.

c. At low temperatures (e.g., -25°C), the performance of the RG 830 filter will be superior to that of the RG 850 filter. This is the result of the wavelength shift of GaAs laser radiation toward the blue at reduced temperatures.

d. Experimental tests at XEOS, in direct sunlight, directly confirm the analytical predictions and are in agreement with predicted values within 3 percent. This is considered excellent agreement and confirms the analysis.

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*Figures C-2, C-3, and C-4 are copies of actual transmission curves for the three filters used.

C.5 RECOMMENDATIONS

a. From a performance standpoint, at room temperature, the RG 830 filter is slightly superior to the RG 850 although either filter would provide good MILES performance.

b. At reduced temperatures, the RG 830 filter is definitely recommended.

c. Since the RG 830 is less costly than the RG 850, has definitely superior low temperature performance, and slightly superior room temperature performance, the overall MILES systems analysis recommendation for a spectral filter is the RG 830.